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## PROCESSING OF COTTON, TEXTILE AND LIGHT INDUSTRY

# INFORMATION MODULES FOR AUTOMATION OF THE PROCESS OF FORMING THE STRUCTURE OF INDUSTRIAL COLLECTION OF WOMEN'S CLOTHING

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**Abstract:** The article discusses the issues of developing information and methodological support for the process of forming an assortment of an industrial collection of women's clothing, taking into account the characteristics of typical figures of various weight and height groups. It is possible to create preferred models and produce garments for figures of various weight and height groups that are not provided by the current range of women's clothing using a basic design developed for average weight and height. The process of transforming the graphic solution of clothing models is carried out by formalizing the search for compositional and constructive solutions, taking into account the accepted geometric shapes of standard figures. To form the structure of assortment collections, based on a study of a large number of analogue models and analogue designs of clothing models based on nominal and quantitative characteristics, a systematized database of geometric patterns of typical divisions and design parameters of the main parts of a woman's dress was formed.

**Keywords:** women's clothing, design and compositional solution, collection formation, product range, search for graphic schemes, typical figures.

The modern market provides consumers with a wide selection of sewing products. When choosing a product, the consumer is guided by the available size chart and the presented product range. At the same time, industrial design produces a product for average height and average fullness due to the labor-intensive process of developing patterns for all available standard figures in the presented standards. It is known that women of different weight and height groups have difficulty choosing fashionable clothes for themselves [1-3].

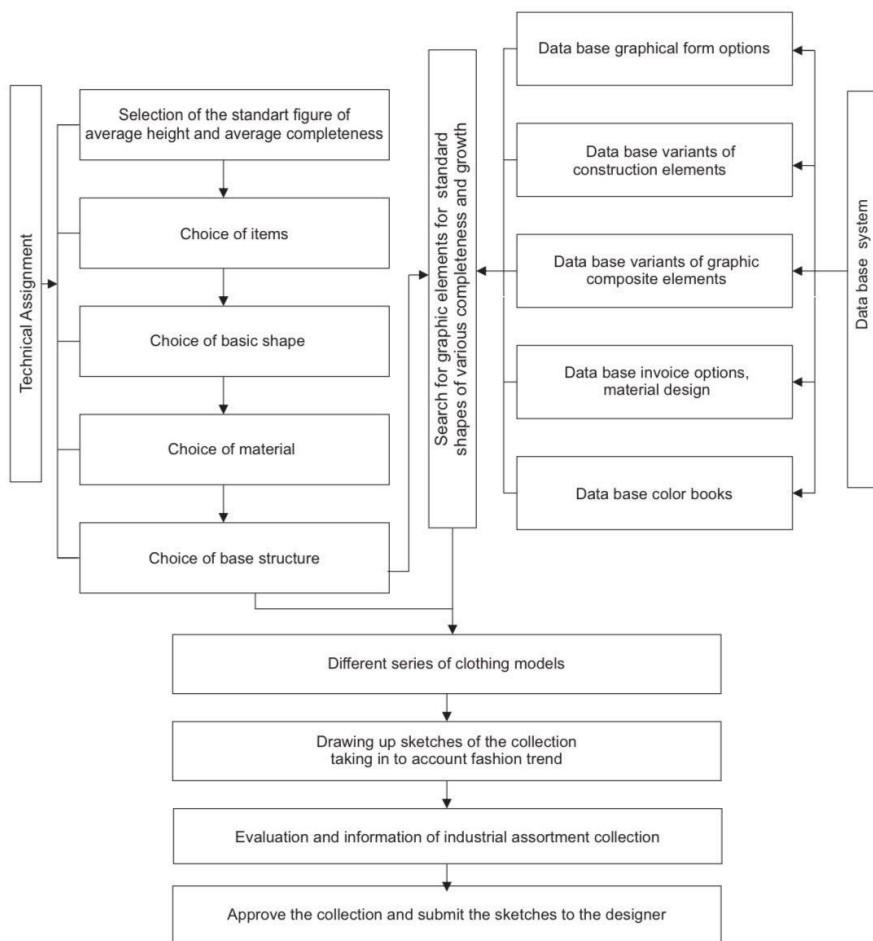
When creating promising clothing collections, the appearance of the model is determined relative to the conditionally ideal (fashionable) human figure, which is set by artists - fashion designers in

sketches and advertising projects and is determined by the artistic directions of promising clothing collections. Conventionally, the ideal figure corresponding to modern standards, according to experts, is determined by the sizes 176-88-92 and 182-92-96 [4,5]. The parameters of the selected figures correspond to the dimensional characteristics of typical figures of the first full group and tall. Consequently, the compositional and structural elements of fashionable clothing are determined by the proportions of a fashionable figure. The development of designs for fashion products for other standard figures of varying stature and stature (SFVSS) requires adjustment of the compositional

and design solutions depending on the type and characteristics of the figure.

The widespread use of digital technologies in clothing production allows the production of customized products focused on the needs of the modern consumer [5-8]. In automated systems, chains of algorithms have been created, including the construction of figure outlines, technical sketches of the product combined with the figure outline, and the development of the product design with a clearly established relationship between their parameters. A method has been proposed for formalizing information on recognizing the design and compositional

characteristics of a model, providing information interconnection at the stages of forming an artistic and technical sketch of a model [8], a method of morphological analysis for synthesizing models of women's dresses based on compositional and constructive solutions, focused on adjacent sizes, allowing to structure the process formation of an assortment of clothing [7]. At the same time, the issue of solving the problem of formalizing the process of forming an assortment collection of women's clothing, covering various height and weight groups based on a basic design developed for average weight and height, requires research.



**Figure 1. Block diagram of the organization of information modules of the database of the process of forming the structure of assortment collections**

The purpose of the work is to develop a structure of information and methodological support for formalizing the process of automated formation of an

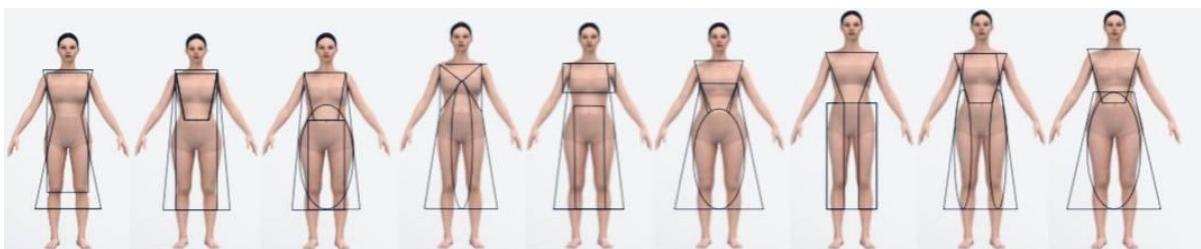
assortment of women's clothing, taking into account the characteristics of typical figures of various weight and height groups at the initial stages of design. The object

chosen is the process of forming an assortment collection of women's dresses for consumers in the mass market segment. Obtaining harmonious models of women's dresses using mixed fiber materials requires determining methods for obtaining the desired shapes and methods of processing products.

Expanding the possibilities of creating harmonious models at the stage of the creative process for SFVSS through the development of a computer-aided design system involves the creation of information modules for converting geometric solutions of the proposed fashionable clothing model based on the selected silhouette shape of the basic design. A block diagram of the organizational structure of the database for the process of forming assortment collections, taking into account the features of SFVSS, is shown in Figure 1.

The algorithm for forming the structure of assortment collections, which involves transforming the graphic solution of a clothing sample taking into account the peculiarities of SFVSS, includes modules of sketching processes with the possibility of using expert recommendations,

intelligent decision support, and artificial intelligence technologies [9,10]. An intelligent module in computer-aided design is based on a technique for coordinating the artistic design of a product with the parameters of the SFVSS. The solution to this problem is based on the development of methods that make it possible to "recognize" graphical solutions of models for SFVSS. The implementation of recognition methods is carried out by expert knowledge that establishes visual and graphic analogies of figurative content and graphic display of a clothing model. When forming the structure of assortment collections, allowing to take into account various weight and height groups, it is necessary to take into account two components: specifying a clothing model for a fashionable figure and specifying an outline of typical figures. The initial information for graphic displays of clothing models is the contour of the figure, which provides illustrativeness, graphic displays and dimensional characteristics of SFVSS, which provide the information aspect of specifying a clothing model [11].



**Figure 2. Development of geometric shapes of the product for the SFVSS figure**

There are known methods for developing harmonious forms of models for standard and individual figures, in which a stylized sketch is adapted for a human figure by correcting the vertical and horizontal parameters of the sketch using a proportioning grid based on an A-rhombus [12], based on the calculation of the slimness coefficient of an individual figure, defined as the ratio of the transverse diameter of the hips to the height and selection of the appropriate basic geometric silhouette shape of the model,

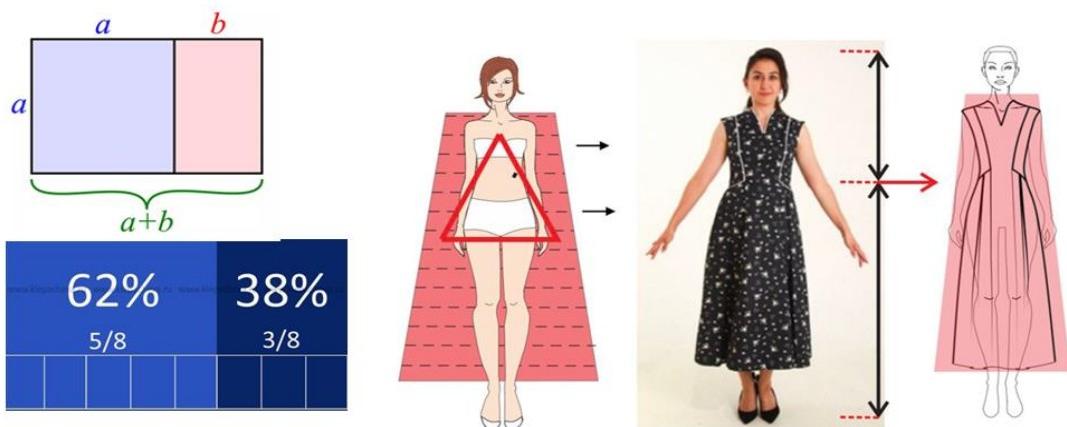
as well as the proportioning of the shapes of clothing models into typical and individual female figures based on the Fibonacci number series [13], a method of geometric harmonization of the shape of a suit based on the additive Fibonacci and Luc series [14], as well as a complex proportioning system based on the A-rhombus and the Hambridge rectangle [15]. In this work, using the above methods of creating harmonious clothing models for various types of figures, a database of basic preferred geometric shapes of

products was generated (Fig. 2).

To create harmonious models for various SFVSS based on the proposed fashionable shape, at the stage of the creative process, it is necessary to solve the problem of optimizing the design solutions of the model depending on the parameters of the basic design of the selected silhouette shape. To identify typical basic designs and design solutions for models, based on a study of a large number of analogue models and analogue designs based on nominal and quantitative characteristics, a database of geometric patterns of typical divisions and design parameters of the main parts of a woman's dress has been generated. At the same time, minimum boundaries for the width of basic structures are established at the horizontal level of the hip line for a large full group.

The main initial information for the formation of the design process for an assortment of women's clothing is the determination of the basic shape of the product and the basic design corresponding to it. The formation of a sketch based on a given artistic representation of a clothing model based on the selected basic design is determined by the connection between the graphic elements of compositional and design

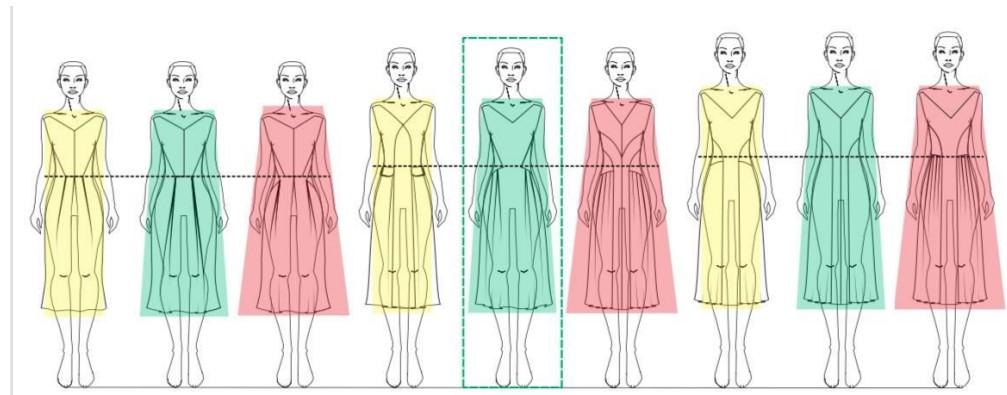
solutions and the outline of the figure for average height and average fullness. The formation of assortment collections of products, taking into account the characteristics of SFVSS, changes the constructive and decorative solution of the model in terms of the size of the outline of the figure and the parameters of geometric shapes, while maintaining the ideological concept of the collection. The basic shape of the model is adapted for SFVSS by adjusting the vertical and horizontal parameters of the model sketch. The preferred position of the projected levels of the bottom line of products, sleeve divisions, yokes, undercuts, decorative details, etc. is determined. The levels of harmonious horizontal lines for various height groups and the value of increases along the hip line are determined in accordance with the fullness group. Using the rules for searching for the necessary graphic solutions at addresses that will have the best combination in the designed model, a graphic structure of the proportional model range of the collection is obtained. Based on an assessment of the resulting graphic structures of the products, the designer develops the collection taking into account fashion trends.



**Figure 3. An example of determining the levels of harmonious horizontals based on the Fibonacci number series**

In accordance with the proposed approach to forming a collection assortment based on a basic model, taking into account the features of SFVSS, a base of elements that make up the graphic solution of a women's dress has been formed. Based on the

Fibonacci number series (Fig. 3), relative to the length of the base model product, the levels of harmonious horizontal lines for various height groups were determined. The graphic design of the artistic design of women's dress models for SFVSS is presented in Figure 4.



**Figure 4. Formation of graphic structures of a woman's dress based on the basic dress model, taking into account the features of SFVSS**

When developing sketches of women's dresses, a database of graphic analogies was used. Based on the proposed shape of the semi-adjacent silhouette of the dress and the basic design selected for its implementation from the graphic database, options for constructive solutions for the form elements corresponding to the SFVSS were determined. In general, for three height and three weight groups, to create a harmonious model, a structural and compositional solution is determined by changing the horizontal and vertical divisions of the model without changing the parameters of the width of the base structure according to the chest circumference. In Figure 4, the fourth complete groups of figures are highlighted in red, in which it is necessary to expand the parameters of the basic design along the hip line by designing folds and gathers, while it is required that the solution found should visually narrow the figure along the hips. For low height groups, the solution found should also visually lengthen the figure. The development of mathematical support for the process of geometric transformation of a clothing model will allow the transformation of the graphic display of the product in an automated mode. The use of a graphical display database in the automated design of clothing collections can significantly reduce the time for design development and reduce the number of errors caused by the human factor. To determine estimates of the compositional solution of clothing models, optimization of varying compositional and design parameters is required. Currently, work is underway to determine the optimality criterion characterizing quality; determining a variety of variable technical parameters; determining the limits of their variation.

The components of the information modules of the system for converting graphic solutions of a clothing model are implemented in the form of test examples and an operating software and methodological complex 3D CLO. Figure 5 shows the results of research on creating models of women's dresses for the mass market segment using various mixed fabrics. The designer can change the color or structure of the fabric of individual clothing items, combine various materials in a collection, obtaining combined colors in accordance with fashion trends.



**Figure 5. Graphic solution of women's dress models, taking into account the features of SFVSS**

Thus, based on a study of methods for displaying a graphic solution of a clothing sample for the development of an industrial collection of women's clothing, satisfying the needs of typical figures of various weight and height groups, a database system of functional modules of design automation systems has been formed. A database of graphic elements of the shape of a woman's dress has been formed and the process of converting graphic information at the creative stages of designing new clothing models has been formalized. The formation of an assortment collection of women's clothing based on the proposed automation approach, which provides an information and retrieval process for graphic solutions of models at the initial stages of design for various typical figures, makes it possible to create original solutions for clothing models, expand the range of products, and also meet the requirements of women of different stature and height groups. The use of a graphical base for displaying a collection in computer-aided design significantly reduces the time for developing the design of women's clothing and reduces the number of errors caused by the human factor.

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## RESEARCH ANALYSIS OF TRANSFORMATION NEW ASSORTMENT DEVELOPMENT

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### Abstract:

**Objective.**The purpose of this scientific research is to develop dynamic, convenient, and bright models of dynamic, convenient, and dynamic assortments based on the analysis and analysis of the creative and transformational assortments of designers from different countries.

**Methods.** In the research, products that change their changing and transformational form, clothes, creativity of designers of different countries, scientific researches are analytically studied.

**Results.** Conclusions were made based on the analysis of the sources, and a new range of dynamic, convenient, bright models of the transformational, shape-changing range were developed.

**Conclusion.** In conclusion, it can be said that various products and clothes made in the form of change and transformation have become one of the current directions of creativity of designers of different countries. In this article, a transformational new assortment design was developed based on the literature review.

**Keywords:** Transformational, changing, assortment, invention, useful model, convenient, functional, harmonious, modern, needs.

**Introduction.** In the 20th century, there was a demand for shape-changing products. In the 1920s, designers began to create universal items that could be used

instead of many traditional items. Various products and clothes made in the form of transformation have become one of the current directions of creativity of designers of different countries [1,2,3,4]. Transformations arise from human needs and try to copy necessary (biomimetics)

ideas and make their inventions more convenient, functional, harmoniously beautiful. Also, modern, fast-changing assortments should be dynamic, convenient, bright, picture 1 shows such items.



Figure 1. Modern changing bags

**Methods.** In the research, products that change their shape and transformation, clothes, the creativity of designers from different countries, scientific researches were analytically studied, and based on the analysis and analysis of the creativity of designers from different countries, a transformational new assortment of dynamic, comfortable, bright model samples was developed.

**Results and discussions.** Many scientific studies have been conducted on transformative changing bags and clothes.

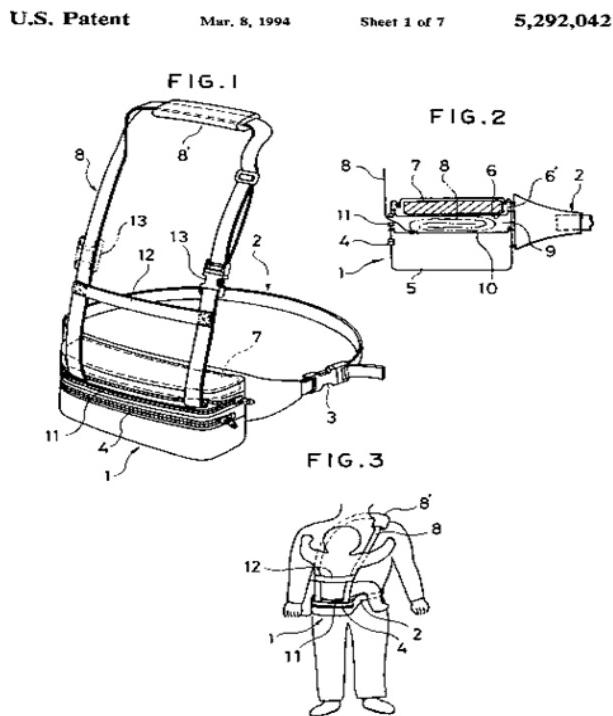
Russian researcher V.E. Bikova has created a versatile packaging handbag for personal items. If the bag is divided into details, it becomes a bag of three different types, its disadvantage is that it is possible to put only light gifts into it, which reduces the scope of use of the bag [5]. N.A. Gennadevych created a useful model for a bag designed to store personal items or a collection of travel accessories [6]. The purpose of the utility model is to increase the efficiency of using the volume of the bag, which includes a bag body with a side pocket. When it opens, it becomes a changing bag, and the upper body of the bag has handles, its advantages are that you can put all your travel essentials in it, and the rest is convenient for carrying personal items [7]. Its disadvantage is the

presence of unused volume due to its large size when opened.

The transformational BAG-BLANG bag is known [8], the bag formed on the side of the bag and the details of the bag are placed on the side walls of the product. The side and details are made of at least two layers of materials, in particular, waterproof and natural materials with natural or synthetic fibers, when the parts are opened, a blanket shape is formed. It also includes a box-shaped appearance organized on the bottom and four sides. The sides are designed to fold in at least one direction, the width and length of the bottom is the same as the width and length of the body when fully opened, and it can be used on beaches. Disadvantages of the method - the lack of usability, the bag can only be used as a blanket on the beach.

Researcher Sumiko Yamaguchi has also conducted many studies on transformational assortments [9,10]. One of them, Sumiko Yamaguchi, Takumichi Yamaguchi invented the transformation backpack. A waist bag can hold small items such as wallets and scarves and is worn around the waist. It was popular among motorcyclists, hikers, and travelers, and made it convenient to carry a child while traveling. The advantages of this invention are that it is convenient to carry the baby with the wallet, it helps to hold the baby in

the arms, and it can be used as a wallet by hanging back when the hand is tired, Figure 3 [11].

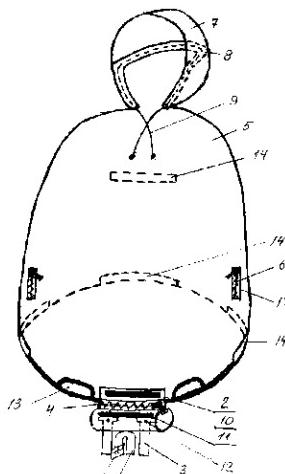


**Figure 2. Transformation backpack**

Susumu Taniguchi designed the baby shoulder bag. This invention is used to carry a baby or toddler along with diapers, cloths and the like, and the baby can be laid down, the disadvantage of this bag is that the inside of the bag is too narrow to fit anything other than the baby's diaper and towel. cannot be used at any other time. [12]. Jeff Zhou and Jason Zhou created a bag for women that comes in three different looks [13]. This bag can be easily used by changing the details, matching it with clothes, combining it. A. Kuznesov developed a useful model for carrying various objects [14]. When fully assembled, this bag is compact and can be used as a small bag to carry small items. When the sides are folded in 2 parts (vertically only), the bag height dimensions change. When the sides and bottom are opened horizontally, the bag changes its dimensions in terms of length and width. When the bottom and sides are fully opened, the bag changes its dimensions in

terms of length, width and height, and the volume of the bag increases up to fifteen times. There are several transformation options of this changing bag, all of which retain the most user-friendly, simple and easy-to-use parallelepiped shape and have enhanced functionality. The main problem of these parallel-opening bags is the limitation of usage possibilities and the presence of unused volume due to the same external dimensions, the low efficiency of using the bag volume with different sizes of transport objects.

Also, bags of different shapes, made of waterproof material, have been created to make it easier to use on a bicycle [15,16,17]. One of them is a convertible hooded bag. It allows you to create a bag by folding its elements and can be used as a cycling jacket even when it rains [18]. The jacket-backpack consists of back and front, pockets and sleeves, hood, inner lining, pocket flaps, pocket linings and fasteners, and is shown in Figure 3.



**Figure 3. Backpack with jacket**

The convertible hooded bag invented. By applying the method of transformation of a backpack with a jacket, the functionality of the clothing is expanded. The technical goal of this useful model is to increase ease of use during transformation. Backpack with jacket is easy to make, weatherproof, lightweight and convenient for country trips.

In order to meet the needs of people, many transformative clothes have been developed, researchers O.V. Chuprova, O.V. Gordeeva, V.A. The Neverovas have created a multi-functional coat. This coat has a double collar and is separated from the waist: the upper part from the waist looks like a suit, and the lower part looks like a skirt, and the pocket part forms a purse [19]. L.L. Chagina, N.A. Smirnova, A.A. Komarova created the "Transformation pants" model [20]. All the seams of the trousers are connected by a lock, when these locks are released, they are divided into 20 details, when these details are combined, 3 figures are formed: shorts, bag, skirt. The disadvantage of both of these models is that there are a lot of details during the transformation, so it takes a lot of time and mistakes to change their shape. There are also a variety of travel bags that change shape. Beach bags that can be turned into special travel blankets are known among them [21, 22]. This assortment is used in trips. The transformation bag is opened by folding the

longitudinal sides of the bag with the right side out in a row, the removable parts are placed on the side folds of the opened blanket, and the bag is turned into a blanket by putting the right sides out. The advantage of the method is ease of use. Disadvantages of the method are the lack of usability, the possibility of using the bag as a blanket only on beaches, the large number of operations to transform it into a transformative form, and the difficulty of production.

Researchers from the Amur State University (Russia) suggested turning the jacket into a backpack when the weather conditions change [23]. The jacket has pockets and a lining, and there are belts between the top and bottom. When turning a jacket into a backpack, the inside pocket of the backpack is turned inside out and the inside of the backpack, the pouch, is formed. To expand the pocket of the backpack, clips are used, which are placed in the pocket. When the back of the pocket and pocket flaps, the sleeves and the hood of the jacket are changed, the pocket is turned outward and the pocket is formed inside. Disadvantages of the method are the large number of operations to convert it from a garment to a backpack, it can only be used as an outer garment that can be folded into itself, nothing can be put inside the bag, and the jacket can be folded as a bag, which has a negative effect on its aesthetic characteristics. the secret

All scientific researches have advantages and ways of solving problems, opportunities given to them. On the basis of scientific research [24, 25, 26, 27, 28] and literature analysis, a new range of transformative bags for children and mothers was developed.

**Conclusion.** Summing up the conducted scientific research and literature analysis, it should be said that many foreign scientists have conducted research in this direction and created assortments of transformational products for various purposes. All research is aimed at solving human problems and finding solutions to them and satisfying human needs. For example, N.A. One bag can be used for two different tasks through the model created by Gennadevich. If you carry money using the bag as a wallet, you can change its shape when you go to the market or on a trip to put personal items or various items and use it to meet your needs without spending extra money on another bag. Also, transformational bags that turn into a

special blanket for travel and make it convenient to use on a bicycle are certainly created based on the needs of people.

All created transformational assortments create comfort and opportunity for people in various conditions. Our Pizdent Sh. Mirziyoyev said "Our main goal is to study the people's problems, find solutions for them, ease their lifestyle by creating favorable conditions and opportunities." Therefore, studying people's problems, increasing the number of transformational assortments that provide convenience for them, and reducing wastage and costs through them are now considered important.

Based on scientific research, marketing research and literature analysis, a new range of mother and baby changing bags has been developed. The aim is to facilitate the lifestyle of mothers and children by creating comfortable conditions wherever they are through the new transformational assortment.

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## EVALUATION OF HEAT CONDUCTIVITY OF SPECIAL CLOTHING

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### Abstract:

**Objective.** The importance of special clothing for workers who are working in closed buildings in the exchange of air (heat) between the human body and the environment has been studied. In this case, as samples of special clothes, the actual special clothes which are made of cotton + polyester fiber fabric of automobile factory workers, the special clothes which are made of 100% cotton fiber fabric taken for comparison, and the special clothes made of cotton + modal fiber fabric is recommended as fabric with high hygienic properties were researched.

**Methods.** In the research used equipment comprehensively determines the temperature, relative humidity, and carbon dioxide content of the environment under clothing and allows the data to be transferred directly to an application on a mobile phone via bluetooth. Based on the obtained results, the

magnitude of the heat flow density between a person - special clothing - external environment was determined using Fourier's law.

**Results.** As a result of the research, it was determined that the value of the heat flow released from the human body is high based on the research of the indicators of the microclimate of the special clothing made from the new (cotton + modal) fiber-containing fabric.

**Conclusion.** From the results of the research, it was found that a large amount of heat exchange occurs between the external environment and special clothing made of cotton + modal fiber fabric. The results of the research revealed that special clothing made of cotton + modal fiber fabric has high hygienic properties.

**Keywords:** special clothing, hygienic properties, modal fiber, thermal conductivity, heat flow, indicators of microclimate under clothing.

**Introduction.** Currently, the use of fabrics produced abroad, the lack of sufficient information about their quality and properties, significantly complicates the design and production of clothing. At the stage of technological processes of clothing preparation, the sudden manifestation of fabric properties affects the quality and consumption indicators of clothes [1]. As special clothing performs the task of improving the working conditions of workers, increasing work productivity and creating comfort for workers during the shift, the task of producing special clothing from fabrics with high hygienic properties is urgent [2-3]. Hygienic properties of special clothing fabrics should be suitable for climatic conditions or labor intensity. Therefore, special clothing should serve to optimize the parameters of the microclimate under the clothing resulting from the physical activities of workers [4-5].

In studies [6-7], clothes made of modal fiber fabrics belonging to the group of natural fibers or artificial fibers were found to be the most suitable for hot, dry climate conditions. Studies have shown [8-9-10] that clothes made of cotton and modal fibers have lower temperatures under clothes than clothes made of other fabrics. The passage of moisture (sweat) through the fabric is a complex process, water vapor diffusion through the pores, sorption-desorption of steam (or droplet liquid sweat) and capillary condensation by fibers and threads occur, especially for fabrics with a dense structure, this process is difficult [11].

Unlike most man-made fibers, modal fiber is considered an environmentally

friendly fiber and is made from wood cellulose. The composition of modal fiber is completely free from toxic substances and other harmful impurities, therefore, this fiber is considered an environmentally friendly and harmless raw material for human health. In addition, fabrics made of modal fiber have a number of advantages over natural fabrics, namely, high hygroscopicity, air permeability, lightness, durability, comfort, softness, etc. Also, despite the chemical composition of modal and cotton fibers being the same, modal has 1.8 times more moisture absorption than cotton. Modal fiber has 50% more moisture absorption than cotton, which makes modal fabrics dry and highly breathable. Therefore, it is considered the best fabric useful for improving the physiological cycle and health of the body [11].

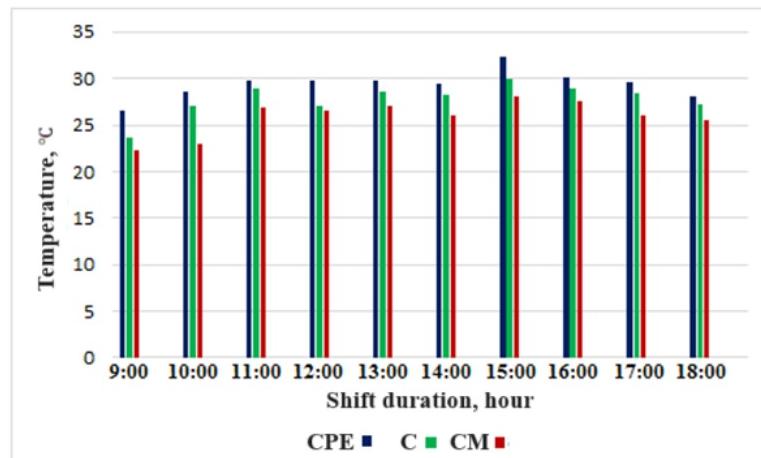
The moisture absorption properties of fabric fibers depend on their chemical composition and molecular structure. Cellulose and protein fibers have high hygroscopic properties. Most synthetic fibers, including polyester (polyether) fibers, have a low rate of moisture absorption, because they almost do not contain hydrophilic groups [12-13]. The above-mentioned properties of modal fiber indicate that the special clothes which are made of fabrics and fibers are optimal for the heat exchange of the human body with the external environment, performing intensive physical activity [14-15-16].

**Methods.** The microclimate under clothing is evaluated by a number of indicators such as air temperature and relative humidity, the amount of carbon

dioxide gas in the air measured in fabrics or clothing items using standard methods in laboratories. In the study, the method and equipment for determining the microclimate parameters were used to determine the comfort of the undergarment environment. The equipment allows to comprehensively determine the temperature, relative humidity and carbon dioxide content of the environment under the clothes and transfer the data directly to the application on the mobile phone via bluetooth [17].

Depending on the type of physical activity of workers during the day, the

indicators of microclimate parameters under special clothing are different. The amount of heat flow released from the body as a result of physical activities of workers affects the temperature of the microclimate under clothing [16]. In the course of the study, the temperature (heat) under the clothes of the workers of the automobile factories during the shift of the special clothes made of cotton + polyester (CPE), 100% cotton fiber (C) and cotton + modal fiber (CM) fabrics taken for control were studied (Figure 1).



**Figure 1. Temperature indicators of the underwear microclimate during the shift**

At 35°C, air movement in industrial buildings creates conditions for increased heat transfer by the body. As the air temperature rises, the moving hot air gives off its heat to a person and begins to warm him. Sudden changes in temperature in the building, for example, cold air blowing (draught), significantly disrupts thermoregulation in the body in winter and causes colds [18]. Therefore, it is very important to study the transmission of air through multi-layer clothing sets. Many researchers have studied different methods of air transfer through fibrous materials [19-20-21]. A number of other researchers have examined the effect of various fabric parameters on their thermal properties and developed models to control air permeability and moisture transfer [22-23-24].

The connection between the heat flux density and the temperature gradient vector is represented by Fourier's law [25-26]. On the basis of this law, it is possible to determine the thermal conductivity of single and multi-layer bodies (including special clothing). The Fourier equation for the elementary layer is as follows:

$$q = \frac{t_1 - t_2}{\delta / \lambda} \quad (1)$$

$\lambda$  – coefficient of thermal conductivity is the most important thermophysical property of materials and characterizes the density of heat flow when the temperature gradient is 1 K/m.  $\lambda$  determined from special tables or by experience;  $\delta$  – thickness of layer (material) (m);  $t$  – temperature at layer boundaries (°C)

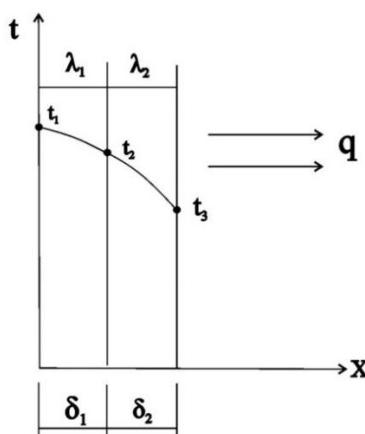
In the research work, the transfer of heat flow in the environment under clothing

to the external environment was studied based on Fourier's law. For this, based on formula (1), the following actions were performed:

$$q = (\lambda_1 / \delta_1)(t_1 - t_2) \quad (2)$$

$$q = (\lambda_2 / \delta_2)(t_2 - t_3) \quad (3)$$

In the stationary (stable) mode, the specific heat flow ( $q$ ) passing through each layer of the material changes depending on the thermal conductivity coefficient and thickness of the material [18]. Figure 2 shows the air (heat) conductivity of two-layer material of different thicknesses.



**Figure 2. Air (heat) conductivity of two-layer material**

**Discussion.** The following results were obtained when the heat flow density between the human body and the T-shirt was calculated based on the formula (2) and the heat flow density between the t-shirt and the special clothing made of cotton + PE fiber fabric was calculated based on the formula (3) in the Excel program (Fig. 3). Here:  $\lambda_1$  and  $\lambda_2$  are thermal conductivity coefficients of the fabric from which T-shirts and special

clothes are made, respectively;  $q_1$  and  $q_2$  are the heat flux density between the human body and the T-shirt and between the T-shirt and special clothing, respectively;  $\delta_1$  and  $\delta_2$  - the thickness of the fabric from which the T-shirt and special clothing are made, respectively;  $t_1$ ,  $t_2$ , and  $t_3$  are temperatures at the boundaries of the human body, T-shirt, and special clothing, respectively.

	B	C	D	E	F	G	H	I	J	K	L
1	$\lambda_1$	$\lambda_2$	$\delta_1$ (m)	$\delta_2$ (m)	$t_3$ (C)	$t_1$ (C)	$t_2$ (C)	$\Delta t_2$	$\Delta t_1$	$q_1$ (J/m <sup>2</sup> )	$q_2$ (J/m <sup>2</sup> )
2	0,22	0,03	0,0015	0,004	26,5	35,8	27,8	1,3	8	1173,333	9,75
3	0,22	0,03	0,0015	0,004	28,6	36	29	0,4	7	1026,667	3
4	0,22	0,03	0,0015	0,004	29,7	36,2	31	1,3	5,2	762,6667	9,75
5	0,22	0,03	0,0015	0,004	29,7	36,4	31,2	1,5	5,2	762,6667	11,25
6	0,22	0,03	0,0015	0,004	29,7	36,6	31,5	1,8	5,1	748	13,5
7	0,22	0,03	0,0015	0,004	29,4	36,6	29,9	0,5	6,7	982,6667	3,75
8	0,22	0,03	0,0015	0,004	32,3	36,8	33,2	0,9	3,6	528	6,75
9	0,22	0,03	0,0015	0,004	30,1	36,7	30,8	0,7	5,9	865,3333	5,25
10	0,22	0,03	0,0015	0,004	29,6	36,6	30,4	0,8	6,2	909,3333	6
11	0,22	0,03	0,0015	0,004	28,1	36,6	30	1,9	6,6	968	14,25

**Figure 3. Heat flux density under special clothing made of cotton +PE fiber fabric**

The following results were obtained when the heat flux density was calculated for special clothing made of cotton fiber fabric (Fig. 4):

	A	B	C	D	E	F	G	H	I	J	K	L
17	t	$\lambda_1$	$\lambda_2$	$\delta_1(m)$	$\delta_2(m)$	t3(C)	t1(C)	t2(C)	$\Delta t_2$	$\Delta t_1$	q1 (J/m <sup>2</sup> )	q2 (J/m <sup>2</sup> )
18	9	0,22	0,21	0,0015	0,004	23,6	35,8	24,1	0,5	11,7	1716	26,25
19	10	0,22	0,21	0,0015	0,004	27	36	27,9	0,9	8,1	1188	47,25
20	11	0,22	0,21	0,0015	0,004	28,9	36,2	29,3	0,4	6,9	1012	21
21	12	0,22	0,21	0,0015	0,004	27,1	36,4	28	0,9	8,4	1232	47,25
22	13	0,22	0,21	0,0015	0,004	28,5	36,6	29,1	0,6	7,5	1100	31,5
23	14	0,22	0,21	0,0015	0,004	29,3	36,6	30	0,7	6,6	968	36,75
24	15	0,22	0,21	0,0015	0,004	29,9	36,8	30,6	0,7	6,2	909,333	36,75
25	16	0,22	0,21	0,0015	0,004	28,9	36,7	29,8	0,9	6,9	1012	47,25
26	17	0,22	0,21	0,0015	0,004	28,4	36,6	29,4	1	7,2	1056	52,5
27	18	0,22	0,21	0,0015	0,004	27,2	36,6	28,2	1	8,4	1232	52,5

Figure 4. Heat flux density under special clothing made of cotton fiber fabric

When the heat flux density was calculated for the recommended special clothing made of cotton + modal fiber fabric (Fig. 5), the following results were obtained:

	A	B	C	D	E	F	G	H	I	J	K	L
32	t	$\lambda_1$	$\lambda_2$	$\delta_1(m)$	$\delta_2(m)$	t3(C)	t1(C)	t2(C)	$\Delta t_2$	$\Delta t_1$	q1 (J/m <sup>2</sup> )	q2 (J/m <sup>2</sup> )
33	9	0,22	4,42	0,0015	0,004	22,3	35,8	22,9	0,6	12,9	1892	663
34	10	0,22	4,42	0,0015	0,004	23	36	23,6	0,6	12,4	1818,67	663
35	11	0,22	4,42	0,0015	0,004	26,9	36,2	27,1	0,2	9,1	1334,67	221
36	12	0,22	4,42	0,0015	0,004	26,9	36,4	27,1	0,2	9,3	1364	221
37	13	0,22	4,42	0,0015	0,004	27	36,6	27,8	0,8	8,8	1290,67	884
38	14	0,22	4,42	0,0015	0,004	26,1	36,6	27,6	1,5	9	1320	1657,5
39	15	0,22	4,42	0,0015	0,004	28,1	36,8	29	0,9	7,8	1144	994,5
40	16	0,22	4,42	0,0015	0,004	27,6	36,7	28,3	0,7	8,4	1232	773,5
41	17	0,22	4,42	0,0015	0,004	26	36,6	27,2	1,2	9,4	1378,67	1326
42	18	0,22	4,42	0,0015	0,004	25,5	36,6	26,3	0,8	10,3	1510,67	884

Figure 5. Heat flux density under special clothing made of cotton+modal fiber fabric

**Results.** A comparative analysis of these obtained indicators is presented in the following diagrams (Figures 6-7).

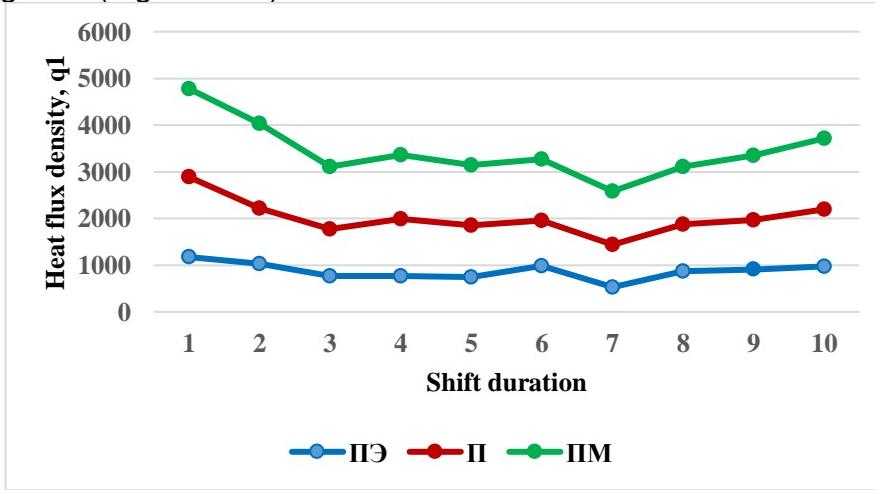
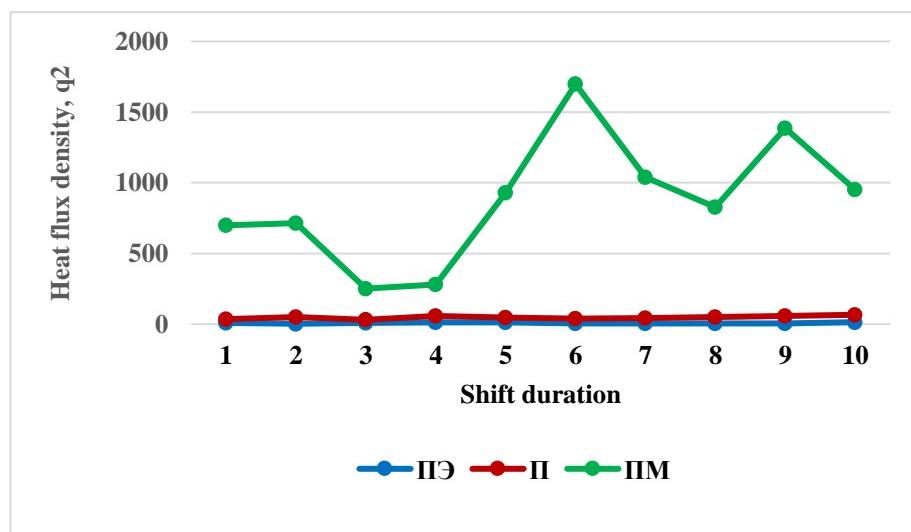


Figure 6. Heat flow in layer 1 (between the human body and the T-shirt)



**Figure 7. Heat flow in layer 2 (between T-shirt and special clothing)**

As can be seen from diagram 6, the heat flux density values in layer 1 (between the human body and the T-shirt) are proportional to each other for all three cases. The reason is that a T-shirt made of cotton fiber forms the layer under the three different types of special clothing.

From diagram 7, it is possible to observe a sharp change in the heat flux density values for three different cases. Because as the 2nd layer, special clothes made of fabrics with different fiber content were taken.

**Conclusion.** Based on the obtained results, it can be concluded that the special clothing made of cotton + modal fiber fabric has the ability to transfer a large amount of

heat flow to the external environment. That is why, as a result of the application of special clothing with high hygienic properties for workers engaged in intensive physical activities in closed buildings (especially car factory workers), their work ability increases, that is, moisture (sweat) released from the worker's body and high temperature modal fiber moisture does not allow the worker to overheat due to the ability to transmit a large amount of heat flow to the outside environment. As a result of the non-occurrence of unpleasant situations caused by the sweating of the worker, there is an opportunity to increase labor productivity.

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## MATHEMATICAL MODEL OF THE INFLUENCE OF A GYMNAST'S STRENGTH ON CLOTHING FABRIC

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**Abstract:**

**Objective.** This article discusses the impact of various forces that can arise during the movement of athletic girls in gymnastics clothes, the study of the stress-strain state, the types of fabric used for clothing, and the mathematical model of the force acting on it. Information about the values of the coefficients determined as a result of the actions is also discussed and highlighted.

**Keywords:** mathematical modeling, physical phenomena, learning, complex dynamic systems, multiplicity, parameters, gymnastics-clothing-environment, human body.

The developed mathematical model of the gymnasts' sportswear system makes it possible to develop a reasonable design and choose the materials of a set of clothes intended for use in conditions of human body movement. The developed mathematical system model "gymnast-clothing-environment" allows us to develop a rational design and selection of the material of a special fabric package designed for use in special conditions of the parameters of the area of movement of the gymnast's body. In world and domestic practice, computer mathematical modeling is widely and successfully used to solve such problems [3].

Mathematical modeling is a method of studying physical phenomena by constructing their mathematical models. So, when studying very complex dynamic systems and objects with a large number of parameters; they are non-linearly interconnected, it is difficult to get the dependence of output indicators on the influence of input, and even more so on changes in the parameters of the system itself. The way out of this situation was found by switching from mathematical models to simulation models. Computer modeling has a much greater potential for the study of complex objects and systems with nonlinear connections [4].

The solution of the problem involves searching for the parameters of gymnastic athletes' clothing and its materials that

meet the requirements, and is aimed at determining the quantitative values of the parameters of clothing for gymnastics, taking into account the reaction of the human body to changes in external conditions. The initial data include human biological characteristics, underwear parameters, sportswear parameters and environmental parameters. For simplicity of mathematical description, the "man-clothes-environment" system is presented as a multi-layered system. The main goal is to develop a mathematical model of clothing that works in the conditions of movement of a gymnast, to study the strength of the material. At the same time, the human body is considered as a deformed cylindrical body of limited dimensions, and clothing is considered as a soft shell. Then the problem under consideration is reduced to modeling deformations of a cylinder with a soft shell. This formulation of the problem allows us to study the state of stress-deformation of the gymnast's clothes, which may occur during the movements of the gymnast. Based on the table below, let's consider a mathematical model of the impact force on the fabric from which the clothes are made during the movement of the gymnast (Table 1).

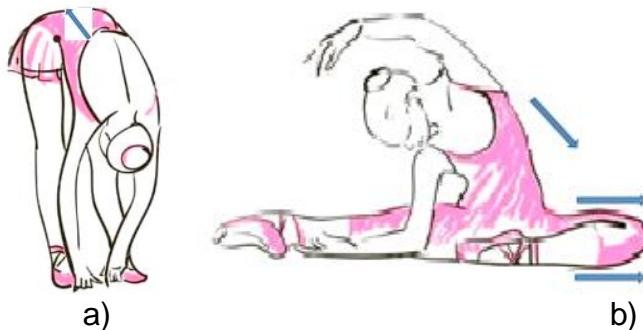
A mathematical model of the influence of a gymnast on the fabric from which the clothes are made.

Table 1

Fabric with three different elasticity					
	removal (N)	Elongation when interrupted (mm)	Durability percentage (%)	Energy expended	Downtime (s)
Rhombus	62	199,7	99,85	3,1	59,93
Tour	<b>254</b>	<b>172,4</b>	<b>86,35</b>	<b>10,9</b>	<b>51,82</b>
Stretch network	113	78,1	39,05	2,9	23,44

The gymnast performs various movements. During movement, the force of movement is directed in different directions depending on the direction of movement, and during bending, the vector force of the human body, as well as the vector force of

attraction of fabric materials, act in opposite directions. With good elasticity of fabric materials, the gymnast will be able to perform tricks with free movement perfectly. The figure shows examples of tricks performed by a gymnast.



**Figure 1. The tricks performed by a gymnast describe the directions of gravity opposite to the directional vector force acting on the fabric applied to the clothing in relation to the directional vector force in human movement**

Based on Table 1, using the mathematical method of least squares, a mathematical model of the tensile strength and elongation (mm) of materials for various situations during the movement of the gymnast was created.

That is, we will use the formula  $Y = A \cdot K^\alpha \cdot L^\beta$  (1) of the work performed as a result of the movement of the gymnast (taking into account the flexion of the joints, it is expressed in the form of the formula  $Y = A \cdot K^\alpha \cdot L^\beta \cdot \cos \gamma$  (1 \*), where the angle at which the joints are curved) [1,2].

Here

A - coefficient of work performed

$\alpha, \beta$  - unknown coefficients ( $\alpha + \beta = 1$  sufficient to satisfy the condition)

K - Force in direction

L - tensile surface of the material (elasticity)

$\cos \gamma$  - angle when bending joints

(1) If we log both parts of the equation

$$\ln(y) = \ln A + \alpha \ln k + \beta \ln L \quad (2)$$

Let us write equation (2) as a function  $A, \alpha, \beta$ .

$$\varphi(A, \alpha, \beta) = \sum_{i=1}^n (\ln(z_i) - (\ln A + \alpha \ln k + \beta \ln L))^2 \quad (3)$$

(2) Differentiate the equation and compose a system of equations

$$\begin{cases} \frac{d\varphi}{dA} = 0 \\ \frac{d\varphi}{d\alpha} = 0 \\ \frac{d\varphi}{d\beta} = 0 \end{cases} \quad (4)$$

Based on condition (4), we will create a system of  $A, \alpha, \beta$  normal equations of three unknowns for calculating linear regression coefficients.

(5) we determine the unknown coefficients of  $A, \alpha, \beta$  (angle  $\gamma$ ) using the normal equation and compile the following table.

Table 2

Nº	K	L	Z	$\ln(k)$	$\ln(l)$	$\ln(z)$	$(\ln(k))^2$	$(\ln(l))^2$	$\ln(x(u))^*l$ $n(y(u))$	$\ln(z(x))^*l$ $n(z(z))$	$\ln(z(u))^*l$ $n(z(z))$
1	2	99,7	99,85	4,1	5,3	4,6	17,0	28,1	2,4	2,2	7,0
2	54	72,4	86,35	5,5	5,1	4,5	30,7	26,5	2,8	2,6	6,7
3	13	8,1	39,05	4,7	4,4	3,7	22,3	19,0	2,3	2,0	4,8
4	29	50,2	225,3	14,4	14,8	12,7	70,0	73,6	7,5	6,7	18,5

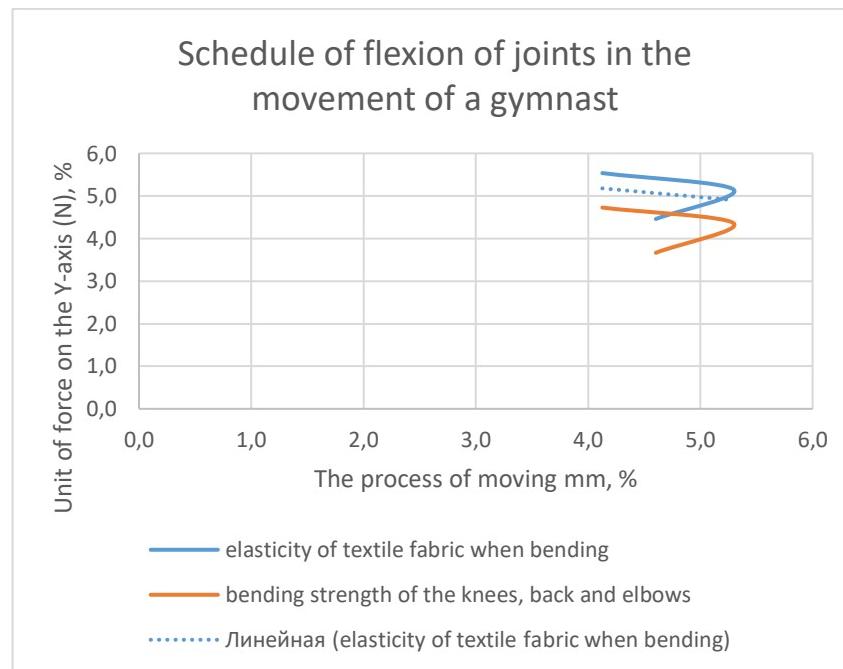


Figure 2. Figure 1 shows the graph (a) of the flexion of the gymnast's joint

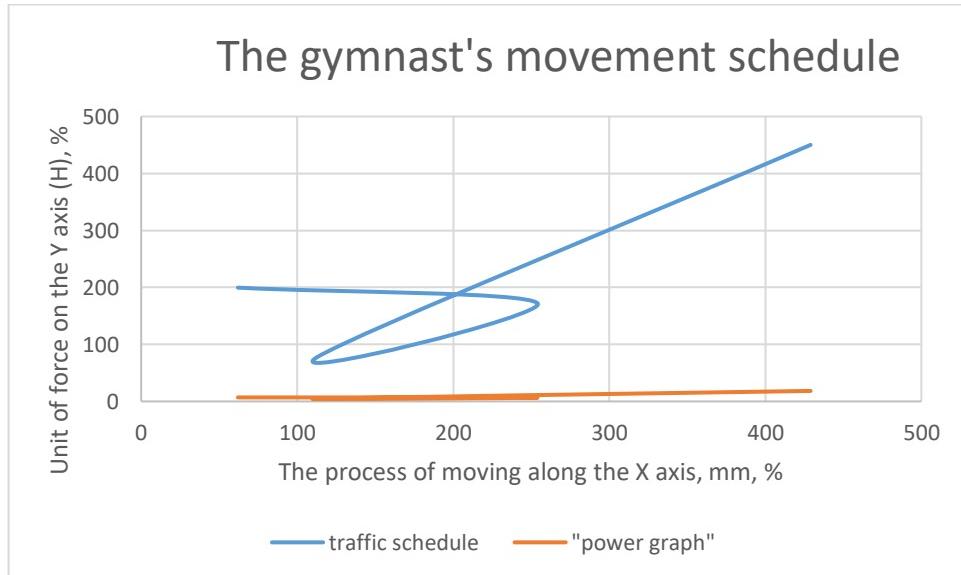


Figure 3. Graph (b) of the flexion of the gymnast's joints is shown in Fig. 1.

The value of certain coefficients as a result of actions is as follows:

$$A=1,305373. \alpha = 1,03664 \beta = -0,03664$$

The high elasticity of materials underlies the tricks performed by the gymnast during movement, based on the values obtained as a result of experiments.

**Conclusion** it is reasonable to say that the cloth placed on the gymnastic girls

in various movements is based on a high level of resistance to the strong contrasts against the clothing force to the direction vector force in the human movement.

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## MODELING OF STRENGTH RELIABILITY AND TRANSFORMATION OF A KNITTED LOOP AT THE LIMIT STATE OF THE STRUCTURE

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### Abstract:

**Objective.** The aim of research is studying the mechanism of strength reliability and transformation of a knitted loop at the limit state of the structure. Comparative analysis of the transformation of the loop of various knitted fabrics, it is advisable to introduce the concept of the average coefficient of transformation of the loop  $\psi_{cp}$  was introduced.

**Methods.** The model of three-stage stretching of knitwear must be borne in mind that the increment of deformation is carried out due to the elongation of the thread on the scale of the loop structure, which occurs after the curved sections of the loop are straightened and the sliding (displacement) of the contact points between the mating loops is completed.

**Results.** Thus, the introduced loop transformation coefficient  $\psi$  can quantitatively characterize the degree of loop variability in the limit state, when the loop step and the height of the loop column take on the maximum possible values. On the other hand, this coefficient may indirectly reflect the mobility of the loop structure.

**Conclusion.** For the considered types of stitches (rib, satin stitch, interlock), of course, the highest mobility has plain ( $\psi_c = 1.456$ ) and the lowest - interlock (0.617), which is explained by the peculiarity of the stitch structure. So, for example, interlock stitch, which is a derivative of an rib, has the largest set of external bonds ("saturation") among the stitches under consideration, which determines the relatively low mobility of the structure.

**Keywords:** knitwear, strength reliability, deformability, structure, knitwear deformation mechanism, transformation of the loop, loop transformation coefficient.

**Introduction.** Unlike woven fabrics, where the structural elements for geometric models are described by relatively simple geometric constructions, in particular, intersecting straight lines (threads) at right angles, and are relatively constant, knitwear has a more complex geometric structure that is easily deformed under the action of an external load.

It is important to note that changes in the structural parameters of textile materials (knitwear, fabrics), including structural changes in thread, occur not only under the influence of mechanical influences, but also shrinkage and contamination as a result of filtration [1]. A set of structural characteristics, such as specific fill indicators, porosity, supporting surface area, translucency, etc., in most cases, are adjusted with thermophysical properties, contact pressure, and frictional interaction. Assessing changes in the structural parameters of a material is the basis for determining the performance properties and functional suitability (reliability) of products.

As is known, knitted fabrics, in comparison with fabrics, are distinguished

by a significant anisotropy of properties, in particular, higher extensibility and low initial modulus of elasticity in the direction of the loop rows than when deformed in the direction of the loop columns. The maximum deformation in the direction of the loop rows and loop columns leads to the limiting state of the loop structure, which is characterized by the transformation of the loop parameters:  $A_0 \rightarrow A_{max}$ ,  $B_0 \rightarrow B_{max}$ .

**Methods.** Considering the model of three-stage stretching of knitwear, it is necessary to keep in mind that the increase in deformation is carried out due to the elongation of the thread on the scale of the loop structure, which occurs after straightening the curved sections of the loop and completing the sliding (displacement) of the contact points between the conjugate loops.

Consider this elongation of a knitted thread under the most unfavorable nature of loading, when the geometric parameters of the loop structure take the highest values ( $A_{max}$  and  $B_{max}$ ) under conditions of uniaxial tension.

The absolute elongation  $\Delta l$  of the thread at break is

$$\Delta l = l_p - l, \text{ mm}$$

where  $l_p$  is the length of the loop thread at break, mm

$l$  - loop length, mm

Relative elongation  $\varepsilon$  of the thread at break, mm

$$\varepsilon = \frac{\Delta l}{l} \text{ or } \varepsilon = \frac{\Delta l}{l} \cdot 100, \text{ \%}$$

The strength reliability condition for axial tension of the thread corresponds to the form

$$\sigma_p = \varepsilon E \leq [\sigma_p], \quad (1)$$

where  $E$  is the modulus of elasticity of the knitted thread, MPa;

$[\sigma_p]$  - allowable normal tensile stress, MPa

When modeling the strength reliability of a knitted thread as a stress  $[\sigma_p]$  it is possible to accept the stress at break  $\sigma_p$ , determined experimentally by the standard method on a tensile testing machine. Thus, based on the above, we get

$$\sigma_p = \frac{l_p - l}{l} \cdot E = \left( \frac{l_p}{l} - 1 \right) \cdot E \leq [\sigma_p],$$

whence the breaking length of the thread will be

$$l_p = l \left( 1 + \frac{\sigma_p}{E} \right) \quad (2)$$

If we substitute the expression for the length of the loop thread into dependence (2), then we finally obtain

$$l_p = 0,0357 \sqrt{\frac{T}{\gamma}} \sigma \left( 1 + \frac{\sigma_p}{E} \right), \quad (3)$$

where  $0,0357 \sqrt{\frac{T}{\gamma}}$ , mm is the nominal diameter of the thread;  $\sigma$  is the loop modulus.

Breaking stress  $\sigma_p$ , MPa - relative load, expressing the ratio of the tensile load  $R_r$  to the cross-sectional area  $S$  of a single sample:

$$\sigma_p = P_p / S, \text{ MPa} \quad (4)$$

It is difficult to calculate the cross-sectional area of a single sample for textile fabrics and therefore, in practice, the breaking stress is determined by the formula [2]

$$\sigma_p = P_0 \gamma, \text{ MPa} \quad (5)$$

where  $\gamma$  is the density of the substance of threads and yarn, g / cm<sup>3</sup>;

$P_0$  - specific breaking load, kN m / kg.

The specific breaking load is used to compare the breaking load of textile fabrics of different weights and is calculated by the formula

$$P_0 = \frac{10^3 P_p}{\rho_s a_p}, \text{ kN m/kg} \quad (6)$$

where  $P_p$  is the absolute breaking load, N;

$\rho_s$  - surface density of the canvas, g/m<sup>2</sup>

$a_p$  is the working width of the sample strip, mm.

**Results.** Using expression (3), one can conduct a detailed analysis of the dependence of the breaking length of the thread on the modulus of the loop, the linear density of the thread, the density of the fiber, and the mechanical properties of the thread. This dependence only in the first approximation gives an estimate of the breaking length, since Hooke's law is of limited use for fibrous materials. Thus, the modulus is most often used for the initial stage of tension at an elongation of 1–2%, when the overwhelming proportion of elongation (up to 95%) is conventionally considered as elastic and therefore is called the "initial modulus of longitudinal elasticity" [3].

Let's calculate the breaking length of the thread in the loop according to dependence (2). To do this, we will first calculate the specific breaking load (6) with the following data: the absolute breaking

load  $P_p$  for the satin surface (cotton yarn 20 tex x 3) is equal to 239 and 123 N, respectively, along the length and width; for an rib (cotton yarn 20 tex x 3) - 673 and 253 N; for interlock (cotton yarn 20 tex x 3) - 610 and 348 [4]; working width of the sample strip  $a_p = 50$  mm. The modulus of elasticity for cotton carded yarn  $E = 1350$  MPa [3].

**Discussion.** The assessment of the breaking length of the thread in the loop is given as a first approximation, since the elastic modulus  $E = 1350$  MPa corresponds to the linear density of cotton yarn equal to 25 tex. The obtained values of the breaking length of the thread most likely correspond to the length of the thread without taking into account the elastic-elastic (reversible) deformations manifested at the moment of destruction of the thread during testing.

Table 1

**Calculated values of the breaking length of the thread in the loop in accordance with the model of strength reliability of the loop structure**

No.	Type of yarn, stitch	Breaking load, N	By length	Width	The surface density of the canvas $p_s$ , g/m <sup>2</sup>	The density of the substance of the yarn Y, g / cm <sup>3</sup>	Specific breaking load $P_0$ , kN m/kg	Breaking stress $\sigma_r$ , MPa	Breaking length of thread $l_p$ , mm
1	cotton yarn, rib	673	253	394	1.52	34.2	52.0	4.885	
2	cotton yarn, plain	239	123	241	1.52	19.8	30.1	4,809	
3	cotton yarn, interlock	610	348	509	1.52	24.0	36.5	5,291	

Consideration of the limiting state of the loop structure, which occurs when the loop parameters  $A_{max}$ ,  $B_{min}$  and  $B_{max}$ ,  $A_{min}$  are combined, makes it possible to quantify the transformation of the loop in relation to the equilibrium state of knitwear. To do this, we introduce the transformation coefficient of the loop along the loop step  $\psi_{III}$ :

$$\psi_{III} = \frac{A_{max} - A_0}{A_0} = A_\varepsilon \quad (7)$$

and the coefficient of transformation of the loop along the loop column  $\psi_c$ :

$$\psi_c = \frac{B_{max} - B_0}{B_0} = B_\varepsilon \quad (8)$$

It should be noted that expressions (4) and (5) are called, respectively, the relative breaking elongation of a knitted loop [5] when stretched along the width and when stretched along the length. However, this interpretation does not seem entirely correct and justified. The fact is that when

deformed, for example, along the width of a knitted fabric, even when the loop pitch  $A_{max}$  is reached, the samples do not collapse instantly. For sample destruction it is necessary to increase the load, which transforms the loop step:  $A_0 \rightarrow A_{max}$ . As the load increases, the threads in the loop experience irreversible (plastic) deformations and only after the plasticity reserve is exhausted does the destruction of the thread occur. As a result of plastic deformation, the length of the thread in the loop, naturally, increases and therefore the corresponding values of the loop step and loop column, exceeding  $A_{max}$  and  $B_{max}$ , should be substituted into the formula, which will constitute an updated value of the relative breaking elongation.

We transform the expression (7) taking into account  $A_{max}$

$$\psi_{III} = \frac{l - 3\pi f - A_0}{A_0},$$

where the length of the loop  $l$  is expressed in terms of the modulus of the loop  $\sigma$  and the conditional diameter of the thread  $d_{yc}$ , corresponding to the minimum thickness of the thread. Therefore, we obtain the dependence for the transformation coefficient of the loop along the loop step

$$\psi_{III} = \frac{\sigma d_{yc} - 3\pi f - A_0}{A_0} = \frac{d_{yc}(\sigma - 3\pi)}{A_0} - 1$$

and finally, taking into account the expression for the conditional diameter of the thread  $d_{yc}$ :

$$\psi_{III} = \frac{0,0357 \sqrt{\frac{T}{\gamma}} (\sigma - 3\pi)}{A_0} - 1 \quad (9)$$

Similarly, we obtain the formula for the maximum transformation coefficient of the loop along the loop column

$$\begin{aligned} \psi_c &= \frac{B_{max} - B_0}{B_0} = \frac{\frac{l-3\pi f}{2} - B_0}{B_0} = \frac{l-3\pi f}{2B_0} - 1 = \frac{\sigma d_{yc} - 3\pi f}{2B_0} - 1 = \frac{d_{yc}(\sigma - 3\pi)}{2B_0} - 1; \\ \psi_c &= \frac{0,0357 \sqrt{\frac{T}{\gamma}} (\sigma - 3\pi)}{2B_0} - 1 \end{aligned} \quad (10)$$

in dependences (9) and (10), the nominal thread diameter  $d_y$  is taken equal to the minimum thread thickness  $f$  [6].

For the possibility of a comparative analysis of the transformation of the loop of various knitted fabrics, it is advisable to introduce the concept of the average coefficient of transformation of the loop  $\psi_{cp}$ , defined as the arithmetic mean of the coefficients:

$$\psi_{cp} = \frac{\psi_{III} + \psi_c}{2},$$

which, taking into account (8) and (9), takes the form

$$\psi_{cp} = \frac{0,0357 \sqrt{\frac{T}{\gamma}} (\sigma - 3\pi) \left( \frac{1}{A_0} + \frac{1}{2B_0} \right)}{2} - 1 \quad (11)$$

**Table 2**  
**Loop transformation ratio values for cotton yarn (20 tex x 3) of various stitches**

No.	Type of yarn, stitch	A <sub>max</sub>	A <sub>0</sub>	in <sub>max</sub>	At <sub>0</sub>	Ψ <sub>III</sub>	Ψ <sub>c</sub>	Ψ <sub>cp</sub>
1	cotton yarn, rib	5.188	1.436	1.297	0.999	1.333	0.436	0.885
2	cotton yarn, plain	2,594	1.112	1,297	0.903	2,613	0.298	1.456
3	cotton yarn, interlock	3,042	1,550	1.521	1,197	0.963	0.271	0.617

**Conclusion.** Thus, the introduced loop transformation coefficient  $\psi$  can quantitatively characterize the degree of loop variability in the limiting state, when the loop step and the height of the loop column take the maximum possible values. On the other hand, this coefficient may indirectly reflect the mobility of the loop structure. For the types of stitches under consideration (rib, satin stitch, interlock), of

course, the highest mobility has the satin stitch ( $\psi_c = 1.456$ ) and the lowest – interlock (0.617), which is explained by the peculiarity of the stitch structure. For example, an interlock stitch, which is a derivative of an rib, has the largest set of external connections (“saturation”) among the stitches under consideration, which predetermines the relatively low mobility of the structure.

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## EXPERIMENTAL DETERMINATION OF THE CLEANING EFFICIENCY OF THE FIBER IN THE PIPE

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### Abstract:

**Objective.** Experimental studies are presented in the article in order to improve the efficiency of fiber cleaning in the pipe in textile enterprises. The device was designed and prepared for experimental research. Based on the results of the experiment conducted on the prepared device, graphs were constructed. The resulting graphs showed that the cleaning efficiency increased with the increase in air speed.

Cleaning the fiber from impurities in textile enterprises consists in increasing the cleaning efficiency of the fiber due to the installation of a special pipe in the front part of the cleaning machine.

**Methods.** When cleaning fibers from impurities in textile enterprises, inclined blades installed at an angle inside the pipe lead to effective separation of impurities from the fibers.

**Results.** From the graph built on the basis of the experiments carried out in the device, it can be seen that the maximum amount of cleaning efficiency of the machine at different levels of fiber contamination, different amounts of air flow, and different work efficiency is when the fiber contamination is 2.5%, the air speed is 20m/s, and the work efficiency is 1200kg/h. The cleaning efficiency is 36 was 9%.

**Conclusion.** In textile enterprises, the fiber cleaning efficiency of the machine is considered one of the main indicators, and it affects the quality of the product obtained in the next technological machines. Based on this, it is advisable to correctly choose the deviation angle of the device and the geometric dimensions of the blades located inside it when cleaning the fiber in the proposed device.

**Keywords:** fiber, pipe, cleaning efficiency, device, air velocity, performance, fiber contamination.

The application of aerodynamics in the textile industry is wide and varied. In addition to the study and control of aerodynamic effects on fiber and fiber structures, all the technology of fiber materials takes place in a viscous air environment. Due to the small mass of fibrous structures and a well-developed surface area, they are greatly affected by air currents, boundary layers of moving

machine elements (for example, sawing gears) and many other effects and technological processes, along with the rotation of working organs [1]. Due to insufficient knowledge of aerodynamic processes, some design features of machines (for example, drum grooves of combing machines) were created based on many years of work experience [2,3].

After breaking the bales in the spinning mill, it is necessary to separate the impurities in the fiber. A special device for the separation of impurities was designed and prepared (Fig. 1). The experimental device consists of an inlet 1, a cleaning mesh surface 2, a waste pipe 3, and a fiber outlet pipe 4. The fibers move through the inlet 1 along with the air flow and are separated from impurities from the surface of the cleaning mesh surface 2, the impurities fall through the waste pipe 3, and the cleaned fibers leave through the outlet pipe 4. Before conducting the experiment, the contamination of the fiber is determined. Determining the cleaning

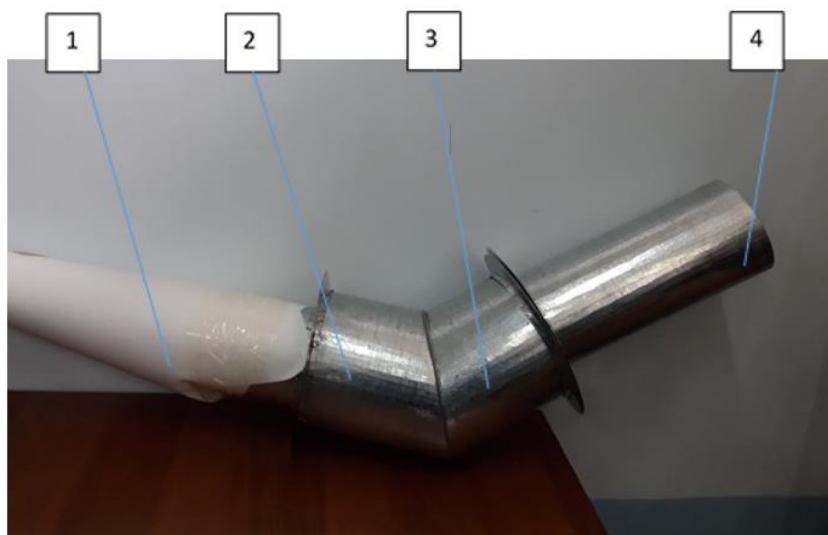
efficiency of the device is determined by the following formula [4-21]:

$$K = \frac{C_1 - C_2}{C_2} * 100\%$$

where K- cleaning efficiency; %;  
 $C_{(1)}$ - dirtiness of fiber before cleaning, %;

$C_{(2)}$ - fiber after cleaning, %.

The experiment is carried out in the following order: The dirtiness of the fiber is determined in a special device. A sample of 500 grams of fiber is taken. The fiber is placed in the inlet and air is introduced. The air velocity was calibrated using a cup-shaped anemometer (Fig. 2).

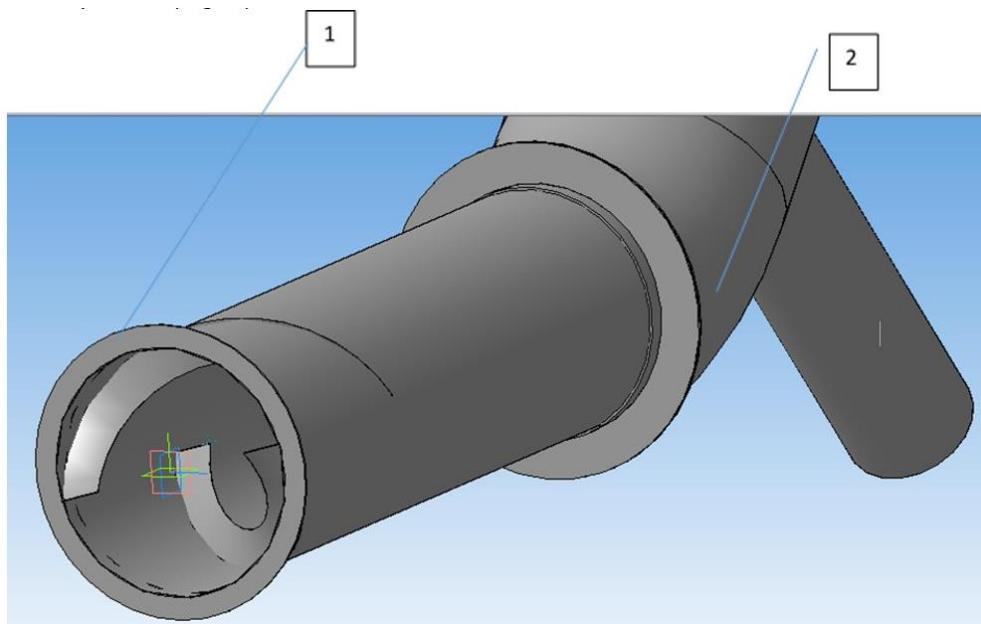


**Figure 1. Fiber cleaning device**  
1-inlet throat; 2-mesh surface; 3-dirt pipe; 4- outlet pipe



**Figure 2. Cup-shaped anemometer**

In order to change the direction of the movement of the fiber in the pipe, the pipes 1 are installed inside the pipe, and the collecting chamber 2 is installed to remove impurities (Fig. 3).



**Figure 3. Paddles (1) installed in the pipe to redirect the fiber movement in the pipe and a collection chamber (2) to remove impurities**

Experiments were carried out at different speeds, impurities and fiber masses. The experiment was carried out for Namangan-77, grade 1, class 2, fiber with 2.5% impurity (Fig. 4).



**Figure 4. Experimental setup**

The results of the experiment are presented in Table 1.

Table 1

S/ n	Impurity of fiber %	Air speed m/s	Productivit y kg/hour	Cleaning efficiency % repetitions				
				1	2	3	4	5
1	2.3	18	1000	34.15	34.09	34.05	34.3	34.02
2	2.4	19	1100	35.6	35.9	35.10	35.4	35.14
3	2.5	20	1200	36.9	34.12	36.14	36.06	34.21
								34.49

The results of the experiment show that the cleaning efficiency of the device increases with the increase of air speed. But it should be noted that due to the fact that the speed of the air increases too

much, the fiber flow speed increases, so the cleaning efficiency decreases. The results of the experiment are presented in graphic form (Figure 5).

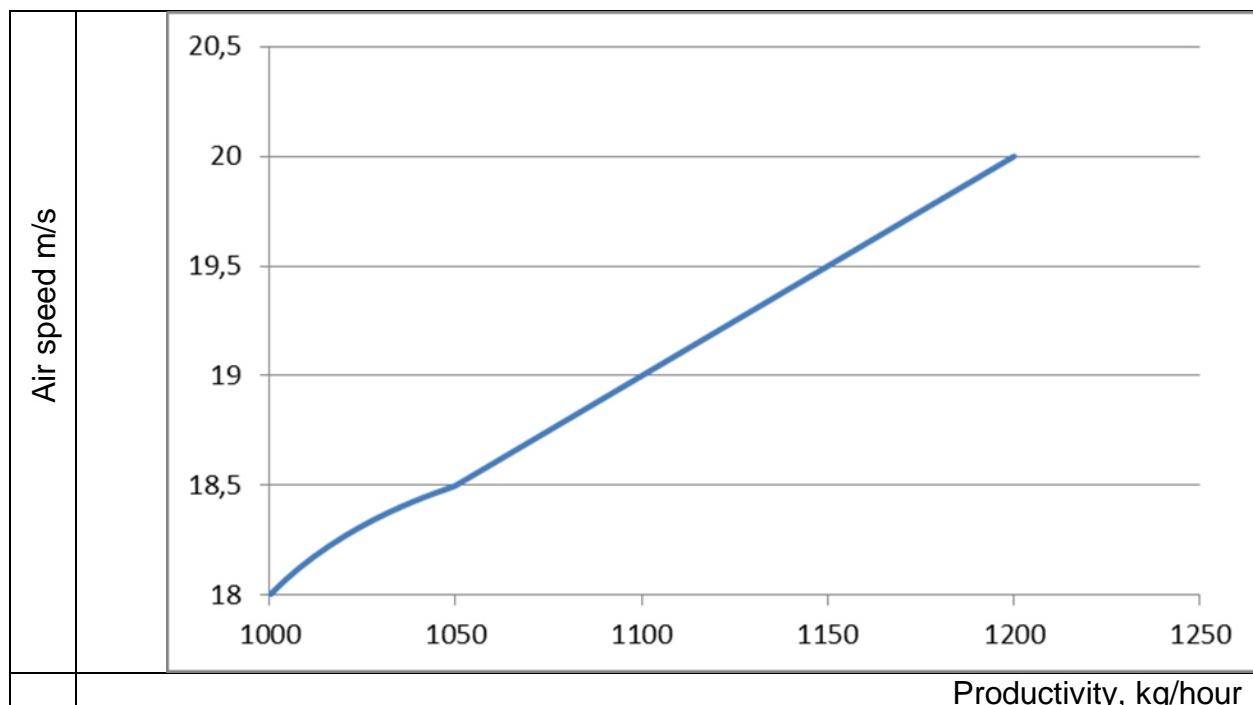


Figure 5. A graph of the dependence of air speed on the performance of fiber cleaning

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## PROBLEMS IN CLEANING COTTON-SEED AND THEIR SOLUTION

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### Abstract:

**Objective.** to identify problems and give recommendations on the processes of cleaning cotton at the cotton gins of the region, taking into account the increase in demand and the need for the use of cotton fiber in the republic and the world in the near future.

**Methods.** analysis of the state of the cotton industry and cotton processing factories in Uzbekistan today, as well as the level of demand and consumption of cotton fiber at the world level. Determine the factors that negatively affect the quality of cotton fiber by studying the activities of cotton processing factories in the regions of the republic. Analysis of the achievements and shortcomings of ongoing research in this direction.

**Results.** in the process of studying the activities of cotton ginning factories in the region (Kosonsoy, Norinsky, Torakorgan, Namangan regions), it was scientifically proven that the YXK cleaning line was used to clean cotton from small impurities, as a result of which the quality of the fiber and seeds was violated due to mechanical impact on pieces of cotton.

**Conclusion.** the development of the correct technological process and the creation of new devices and equipment for obtaining high-quality products from raw cotton at ginneries is of particular importance.

**Keywords:** raw cotton, textile industry, cotton industry, updating technology, cotton fiber consumption, ginneries, raw cotton quality, development program, material and technical base, number of neps (entangled fibers), cotton impurities, seed damage.

**Introduction.** Cotton is the economic backbone of our country. Therefore, today the state creates ample opportunities to ensure private initiative in the industry, produce products in accordance with existing international standards, bring cotton industry products to international markets, further develop international cooperation in the industry, and attract large international branded enterprises in the textile industry to the investment network[1,2].

It is known that the international coalition Cotton Campaign announced the end of the boycott of Uzbek cotton, and in recent years in other consumer countries, interest in our cotton and products of our textile industry has been growing. The global cotton market is expected to reach US\$46.5 billion by 2027, with a CAGR of 2.74% between 2020 and 2027.

Therefore, in cooperation with the secretariat of the International Advisory Committee (IAC) to further enhance the prestige of the Uzbek cotton industry in the world market, a number of successes were achieved following the results of the 76th IAC plenary meeting on the theme "Cotton in the era of globalization and technological development" and the XIII International Uzbek Cotton and Textile Fair (with the participation of about 1,500 foreign guests from more than 44 countries and local experts) and many other events. At such events, open and thematic problems related to the development of the cotton and textile industry in cotton-growing countries, trends in the global cotton market, trade, logistics and insurance issues were considered, and ways to solve them in cooperation were proposed. Such activities allow us to fully solve the

problems that have arisen in the global environment. In addition, it invites experts in the field to exchange ideas, improve skills and take a scientific approach to the problem.

In addition to the above, issues of genetics and biotechnology for creating cotton breeding varieties, agrotechnics for growing cotton, protecting it from pests and diseases were widely discussed. In particular, the importance of paying special attention to the problems and achievements in the field of primary processing of cotton, instrumental assessment of the quality of cotton fiber, and its processing by textiles was noted. We see that almost all issues discussed at the event are aimed at a comprehensive improvement in the quality of cotton fiber.

**Methods:** As a result of the measures taken by the state to improve the system of preparation of raw cotton and optimize the methods and technologies of primary processing of cotton, today the share of fibers of the "High" and "Good" classes amounted to 92.0% of the total volume of cotton fiber, which is 10% more than last year. 99% of all manufactured fibers have a micron index of 3.5-4.9 and comply with international requirements. The length of the fiber produced has also improved somewhat. In particular, the share of fiber code 37 in the season increased from 21% to 23%. The proportion of fiber type 4 was 85 percent.

Due to the increase in demand for cotton fiber in Uzbekistan, consumption is expected to increase in the coming years. Therefore, the state plans to implement dozens of investment projects as part of the development program until 2026. The implementation of these projects will bring

the level of processing of cotton fiber to 100% of the total production and increase the export potential of the Uzbek industry by more than 3 times [2].

A Concept and a program for the development of the cotton industry of the Republic of Uzbekistan for the period up to 2030 have been developed. To ensure the implementation of the program in practice, it is necessary to analyze the current state of the equipment and technologies necessary for the pre-treatment of cotton raw materials, and identify a number of problems. It is known that the quality of the harvested cotton and the fiber obtained as a result of its processing depends on many factors, including: the timely collection of cotton and its receipt at ginneries, cleaning operations, removing moisture and dirt as necessary, and warehouse work. However, even in modern conditions of such work, the quality of cotton fiber cannot be recognized at the proper level. It is these shortcomings that make the modernization work at cotton ginning enterprises, as well as the further improvement of the material and technical base, a task of everyday life.

These negative reasons mainly include: the presence of foreign heavy impurities (stones, scraps, etc.) in cotton shipped from cotton mills. To date, according to the conclusions made by international experts, including Chinese, to the cotton fiber of Uzbekistan: low competitiveness of cultivated cotton, poor cleaning quality and a large number of neps (tangled fibers) in cotton fiber; it is noted that cotton fiber is not cleaned enough, resulting in quality fiber does not meet the required level.<sup>2</sup> Such an assessment of Uzbek cotton in the international field prompted us to study the processes of cotton processing in more depth.

**Results.** In the process of studying the work of cotton ginning plants in the

region (Kosonsoy, Norinsky, Torakorgan, Namangan regions), the following stages of work were observed and analyzed: 1) drying of raw cotton (drying using 2 SB-10 - drying drums); 2) cleaning shop (dried cotton raw materials are cleaned from large and small impurities on the USC cleaning line); 3) separation of fiber from purified cotton raw materials (separation of fiber from seeds at plant 5 DP-130 (gin)); 4) press shop (fiber spinning is carried out in the press shop using press equipment DB-8237); 5) weighing packing fiber on electronic scales (weighing on electronic scales and transferring finished products to the warehouse using a belt conveyor); 6) extraction of fluff from seeds (VP - fluff is extracted from seeds in fluff aggregates); 7) backfilling of fluff (filled in the DA-237 pressing equipment and fluff is weighed on electronic scales and transferred to the finished product warehouse. The seed product is weighed on electronic scales and fed to the seed warehouse through an elevator and augers).

When considering the above 7-stage process, the quality of raw cotton is at the required level at the initial stages of cotton harvesting (Fig. 1-a), and there are few problems with its processing at the plant, but at the middle and late stages of harvesting, the quality of the resulting cotton fiber deteriorates due to the influence of various impurities, etc. on the quality of the fiber (Fig. 1-b).

Various problems arise during the processing of such cotton at the plant, especially at the 2nd stage of the process, that is, at the UXK cleaning line, in the process of cleaning from coarse and fine impurities, on the one hand, while the impurities contained in raw cotton are practically cleaned, on the other hand, it is observed that a piece of cotton during this process is divided into smaller pieces (Fig. 1c).

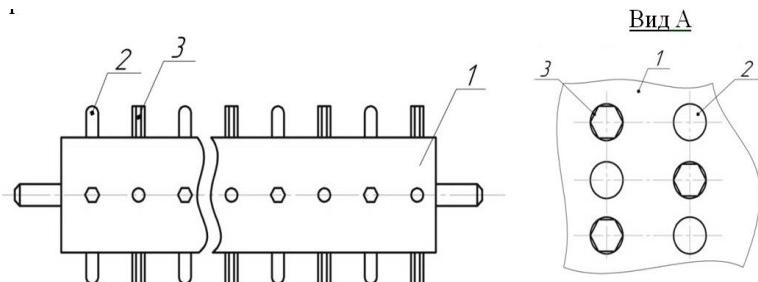


**Fig. 1. Raw cotton cases:**

a) cotton collected in the primary collection; b) cotton picked in the middle and at the end of the cotton harvest; c) Cleaned cotton after UXK cleaner

It is known that recently a drum with pile has been used in the cleaning department of the YXK type cotton gin (Fig. 2). As we can see, 2 types of hammers were used here: bladeless and blade hammers. Although the use of blade hammers increases the efficiency of cleaning cotton by 20%, on the other hand,

it can cause significant (750-800 million soums) economic damage to an enterprise producing 20-25 thousand tons of cotton fiber per year due to seed damage. In addition, it is natural to increase the number of short fibers (neps) in the fiber composition. This situation leads to a decrease in fiber quality.



**Fig. 2. A pile drum used in a cotton cleaner**

1- drum; 2- bladeless hammers; 3-6-blade hammers

In the analysis of studies conducted by the specialists of the Mingbulok cotton ginning enterprise, which is part of the ART SOFT CLUSTER HOLDING company, with the cleaning efficiency of the 1XK machine (23-29 percent), the Namangan-77 variety, the 1st grade and the 1st group received piece fiber: dirt - 0.5%, seed husk - 0.8%, broken seeds - 0.5%, immature seed fiber - 0.5%, immature fiber fragment - 0.1%, tangled fibers - 0.1%, the percentage of total impurities and defects was 2.5% [4].

As a result of the division of cotton fiber into groups according to impurities and defects, the following results were obtained, the percentage of defects and

impurities in the 1st grade: high - 2.0%; good-2.5%; average-3.0%; simple-4.0%; dirty - 5.5%, average in this class - 3.3%; The percentage of defects and impurities in the 2nd grade: high - 2.5%; good-3.5%; average-4.5%; simple-5.5%; dirty - 7.0%, average in this class - 4.6%; The percentage of rejects and impurities in grade 3: good - 4.0%; average-5.5%; simple - 7.5%; dirty - 10.0%, average in this class - 6.7%; The percentage of defects and impurities in grade 4: good-6.0%; average-8.5%; simple - 10.5%; dirty - 14.0%, average in this class - 9.7%; The percentage of defects and impurities in grade 5: average - 10.5%; simple - 12.5%;

dirty -16.0%, it can be seen that the average in this class is -13%. From the foregoing, we can conclude that an increase in the category (1-5) leads to an increase in the proportion of defects and impurities in the class, that is: in the highest class - by 0.5%; in a good class - by 3.5%; in the middle class - by 7.5%; in the regular class - by 8.5%; it can be seen that in the dirty class it increased by 10.5%.

Further, after determining the parameters of the pile drum chipping, improved by researchers in order to increase the cleaning efficiency of the separator-cleaner, taking into account the importance of studying the distance between the ends of the strap and the chipping and the mesh surface, the drum rotation speed for the cleaning action and

mechanical damage to the seeds, the distance between the pile top and the mesh surface in the device 12; 14; 16; Transition to 18 mm, the number of revolutions of the drum 400; 420; The experiments were carried out at a setting of 440 rpm. Cotton of the I technical grade with a dirtiness of 6.2% and a moisture content of 8.8% was used. The results of the experiment are presented in Table 1 [5].

At the same time, due to a change in the number of turns and the distance between the mesh surface and the tip of the pile (in the 1XK cleaning unit), we see that the cleaning efficiency has changed (Table 1), but it was found that with these changes, seed damage increased from 0.8% to 1.2%.

Table 1

No	circ/quantity	Distance from the wall surface to the tip of the pile, mm	cleaning effect, %	Increased mechanical damage to seeds, %
1.	400	12	3,4	0,8
		14	3,2	0,6
		16	2,8	0,5
		18	2,6	0,5
		12	4,5	0,9
		14	4,4	0,7
2.	420	16	3,8	0,5
		18	3,2	0,5
		12	4,2	1,2
		14	4,0	1,0
		16	3,6	0,8
3.	440	18	3,0	0,8

From the above study, it can be concluded that the use of a pile drum in the cleaning section of cotton-cleaning devices, on the one hand, increases the cleaning efficiency (increases the profit of the enterprise), on the other hand, increases seed spoilage. This situation leads to the fact that the company does not have enough seeds for seed production in the future. Therefore, in the future, we will need to develop completely new technologies for cleaning raw cotton from small impurities.

In this regard, based on the results obtained on the creation of an improved

technology for cleaning cotton from impurities, the "Pakhtasanoat Scientific Center", Tashkent Institute of Textile and Light Industry, Namangan Institute of Engineering and Technology, Namangan Engineering and Construction Institute and other universities are conducting research on an improved cotton ginning plant that performs vertical cleaning of raw cotton. However, modern requirements require the modernization of the cotton ginning industry, the active implementation of technical and technological re-equipment, the need to use changeable technologies that do not affect the natural properties of

cotton in the ginning process and ensure the production of competitive products.

**Conclusion:** it is natural that high-quality fiber products will be in high demand in international markets in the future, otherwise there will be a "fewer buyers" situation. Of particular importance is the development of the correct

technological process and the creation of new equipment for obtaining high-quality products from raw cotton at ginneries. If the technological process of the enterprise is developed correctly, then the cost of the resulting product and production costs will decrease, and the enterprise will receive a good profit.

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## GROWING, STORAGE, PROCESSING OF AGRICULTURAL PRODUCTS AND FOOD TECHNOLOGIES

# DEVELOPMENT PROSPECTS OF THE OIL PRODUCTION INDUSTRY IN THE REPUBLIC OF UZBEKISTAN AND FOREIGN COUNTRIES

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**Abstract:** High-performance mills equipped with modern equipment in the Republic of Uzbekistan. Technological processes in mills and flour mills in foreign countries do not fundamentally differ from technological processes used in factories in the Republic of Uzbekistan. Attention is paid to the quality of flour, which is compared with the constructions of machines used only in technological processes.

**Keywords:** Industry, nutrition, crushed shells, physiological function, protein, starch, minerals, particles, finely dispersed, buckwheat, oats, grain, nutritional value, rye, mills, hygroscopic, powdery, dose, flour, production.

**Introduction.** The development of the flour production industry is mainly a product that is produced during the milling process of grain, if it is obtained only from the inner part of the grain - the endosperm - this type of flour is called wholemeal flour when it is milled together with the husks and husks of the grain. Grains of wheat, rye, triticale, small amounts of oats, buckwheat, barley, corn and other crops are used for flour production. Flour is the basis for the preparation of food products. As a result of their consumption, a person satisfies the need for 30- 50% protein and 20-40% for various necessary biological substances.

The most valuable in terms of nutrition is simple ground flour, which contains many nutrients. In addition, flour contains fibrous substances due to crushed shells, which affect the release of various slags in the digestive tract and improve the physiological functions of the intestines. In modern mills, it is possible to develop different types of flour with increased and decreased content of protein, starch, minerals and vitamins.

In the Republic of Uzbekistan, there are high-efficiency mills equipped with modern equipment (mills with a capacity of 250 to 500 tons per day) and grain factories. Up to 75% high quality flour is obtained in these mills. Currently, small mills with a capacity of 50 tons are being built in our republic. Technological processes in mills and grain factories in foreign countries do not fundamentally differ from technological processes used in factories in the Republic of Uzbekistan. It differs only in the construction of machines used in technological processes.

One of the main directions of development in the field of flour weighing is the processing of grain to obtain new products, including the technology of obtaining flour and composite mixtures and its application. VNIIZ DIB developed the technology of making flour from oat, barley, millet, vitaminized, vitamin and mineral mixtures, in addition to which other cereal products - bran, fully ground grain and wheat bran are added. A big role in the expansion of the assortment is focused on the use of ingredients.

They make it possible to use grain with high quality, nutritional value, dietary and preventive treatment. It is known that in grain processing, there is a need to adjust the quality of flour in order to satisfy the need for high and stable quality flour of bakeries and other enterprises. In foreign mills, for this purpose, wheat flour is added to improve the quality of bread, for example, an enzyme preparation containing 2-amylase.

In Russia, the use of improvers to increase feed value and ensure the production of flour meeting standard requirements is at the initial stage. Differences in soil-climatic agrotechnical and other conditions of grain development lead to considerable fluctuations in its quality, and this fact was confirmed when researching the harvest of recent years. Due to the different quality of grain batches, the problem of stabilizing the quality of weighing batches arises.

In addition, the quality of wheat grain has been decreasing in recent years. Yuqori tovar sifatiga mansub bug'doy amalda qolmayapti, tovarbop aksariyat qismi past (3-5) sinfga xos bo'lgan donlardir. According to the data of the state grain inspection, 65% of the wheat harvest in Russia in 2012 belonged to 3-4 classes, and 30-74% of it, depending on the region, was 4th class. The remaining 35% of commercial wheat grain is included in non-food grains. Russian flour mills process 80% per year fermented grains with low or unsatisfactory quality gluten, with high or low activity. urtle-like - mite, bruised, cold-hit, high-temperature dried grains are among them.

**Materials and methods:** One of the ways to improve the baking properties of flour is to use special processing technologies that allow to separate the defective diseased grains or anatomic parts that worsen the baking properties.

The use of baking quality improvers is one of the convenient ways to control the quality of flour and bread. This situation allows control and forecasting with

sufficient accuracy. Unfortunately, this thing is used in practice only in baking enterprises.

Currently, importance is attached to the use of complex enhancers. They affect different substances of flour at the same time. The improver should have a certain size, powdery, no larger than the size of flour particles, well sprinkled for exact dosing and finely dispersed nature that can mix well with flour. Its moisture and hygroscopicity is low, its color is light, it does not change the color of the flour, and its shelf life should not be less than that of wheat flour. Although the enhancer is relatively cheap, its use should be economically feasible. One of the important moments of choosing an improver is to take into account its properties and characteristics, checking its compatibility with the quality of concrete flour.

As a result of the annual analysis of the harvest, it was found that the main reason for the deterioration of the marketability of wheat grain is the low amount of gluten. Even in wheat grain of the 3rd class, the amount of gluten is at a lower level and does not exceed 23%. Flour produced from 3rd class wheat does not always meet the requirements of GOST 26574-85. Dry wheat gluten is added to the low gluten content to improve its baking properties. It meets the requirements of flour production. Dry wheat gluten exhibits a finely dispersed, light-colored powder, has low moisture, flows well, allows to correct the common defects of low-quality flour without worsening the organoleptic indicators of flour. Dry gluten is a natural substance and its amount is not limited when used as an additive. Flour mills in

France, the USA and other countries add dry wheat gluten to flours that are already low in protein. In European countries, adding dry wheat gluten to the weak, expensive wheat improver saves money. In Russia, dry gluten is mostly added to bakery improvers. This makes it possible to increase the water absorption capacity of the dough, to improve its

physical properties, to increase the quality indicators of bread, including the structural-mechanical properties of the core, the yield and shelf life of bread-loaf products. VINIIZ DIB multi-faceted studies were conducted by, in which a number of cardinal problems regarding dry gluten were solved. In particular, technological properties of different dry gluten samples are analyzed, evaluation of the quality of flour enriched with dry wheat gluten, as well as studies of the properties of dough and baked bread were carried out. An express and objective method has been developed at the institute to assess the quality of dry wheat gluten using the mechanized NOC system. With its help, dry wheat enriched with gluten is checked for changes in the amount and

quality of gluten, as well as the dose of dry gluten.

**Results.** In our work, we experimentally added dry wheat gluten obtained from wheat grain of the 4th grade "Starshina" to it, and the amount of wet gluten in each dose of dry wheat gluten was 1 We found that it increased by 6-2% (Table 1).

It is enough to add 2-4% of dry wheat gluten to bring the quality of flour obtained from class 4 grain to the level of TSH requirements or to the level of GOST 26574 standard. The volume of the high grade bread increased by 90 cm<sup>3</sup>, and that of the 1st grade increased by 116-118 cm<sup>3</sup>. The increase in the shape of bread obtained from it of the first grade reached from 0.34 to 0.37-0.38.

Table 1

#### Changes in the baking properties of flour due to the addition of dry wheat gluten

No	Event named	The result achieved
1	In each added percentage of dry wheat gluten	Flour gluten increased by 1.6-2%
2	Add dry wheat gluten in the amount of 2-4%	The quality of the flour obtained from the 4th grade grain met the requirements of GOST 26574
3	Add dry wheat gluten in the amount of 2-4%	the volume of the flour loaf is 90 cm <sup>3</sup> 1n. the volume of the flour loaf has increased to 116-118 cm <sup>3</sup>
4	Maximum added dose of dry wheat gluten	Not more than 4%
5	Addition of dry wheat gluten in the amount of 3-4%	The quality of flour gluten It ensures the transition from the IIIunsatisfied weak group to the IIsatisfied weak group.

**Conclusion.** When adding dry wheat gluten, the physical properties of dough made from weak flour reached the level of strong dough. Adding more than 4% dry wheat gluten does not improve the baking properties of the flour muchTherefore, it is recommended to add 3-4% dry wheat gluten to the baking flour.

As a result of adding dry wheat gluten in a dose of 3-4%, it is ensured that the

quality of gluten changes from III-unsatisfactory weak group to II-weakly satisfactory group.

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## KINETICS OF DRYING PROCESS OF TOMATO FRUIT

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### Abstract:

**Objective.** The scientific research shows studies on the analysis of the kinetic laws of the drying process of tomato fruit were carried out. Non-traditional methods of heat treatment are proposed, based on low-temperature drying regimes aimed at preserving the biologically active substances contained in the tomato fruit. The molecular movement of liquid droplets in the product and the laws of movement of moisture towards the surface in the appropriate wavelength range of infrared light were studied on the basis of experiments.

**Methods.** On the basis of full-factorial experiments, the threshold values of the parameters affecting the drying process of tomato fruit were determined. In the initial stage of the period of heating and constant drying speed of the product, pulse treatment in the wavelength range of  $0.7\div1.1 \mu\text{m}$  of infrared light, and in the period of decreasing moisture content of the product, use of continuous drying method in the wavelength range of infrared light of  $2.4\div2.8 \mu\text{m}$  based on A drying device designed for processing tomato fruit based on pulse mode and continuous drying at low temperature has been developed.

**Results.** By using the non-traditional drying method, the results representing the drying curves of tomato fruit with a thickness of 8, 10, 15 mm and the drying process speed curves were obtained. The results show that 34-35% of the moisture content of the 8 mm thick tomato, 25-26% of the 10 mm thick tomato fruit, and 14-15% of the 15 mm thick tomato fruit content were experimentally confirmed.

**Keywords:** drying, equilibrium humidity, desorption, heat capacity density, wavelength, equilibrium humidity.

**Introduction.** In the world, a number of scientific research works are being carried out on the creation of techniques and technologies for drying agricultural products, production of canned ready-made products [2,3,6,16]. Development of drying devices and regimes that allow preserving BAS (biologically active substances) in the product by using modern methods of energy impact in the drying system, researching the kinetic laws of the drying process for the entire volume of the product, as well as developing

scientific research aimed at accelerating metabolic processes are current issues. Based on these tasks, the issue of experimental research of the kinetic laws of the drying process of tomatoes grown in the open fields and greenhouses of our Republic is expressed in this article.

**Methods.** On the basis of theoretical and experimental studies, the analysis of the kinetic laws of the tomato fruit drying process was carried out [8,9,12]. A drying device designed for low-temperature drying of tomato varieties grown in the

open air was developed, and based on the relevant equations, the change in the amount of moisture released from the tomato fruit per unit of time was determined [10]. The drying process of tomato fruit varieties "Alamingo", "Sultan", "Moderna" and "Tashkent" was carried out, and the change of moisture in the samples with the size  $\delta=8$  mm,  $\delta=10$  mm and  $\delta=15$  mm was experimentally studied (1,2,3 Tables). In the theory of drying, the moisture content of the product is usually calculated in relation to the mass of the completely dry product, which remains intact during the drying process, which in turn provides great convenience for calculations. Accordingly, the total mass of the tomato fruit is: [1,7,11,17].

$$G = G_{wet} + G_{adm} \quad (1)$$

where:  $G_{wet}$  - the amount of water in the raw material, kg,

The moisture content of the tomato fruit in relation to the total mass:

$$W = \frac{G_{wet}}{G} \cdot 100 \quad (2)$$

The amount of absolute dry matter in tomato fruit is determined by the following equation:

$$G_{adm} = G_b / (1 + w_b^d) \quad (3)$$

where:  $G_b$  is the initial mass of the product, kg;  $w_b^d$  - initial moisture content of the product, %.

From this equation, the moisture content of the product, kg.moisture/kg.dry substance:

$$(W^d = G_b - G_{adm}) / G_{adm} \quad (4)$$

**Results.** In the study of drying kinetics, the drying process of tomato fruit with initial moisture content of 94÷95%, dry matter content of 5.0÷5.3 % and mass ( $m=1384$ gr, Table 1;  $m=1367$ gr, Table 2;  $m=1052$ gr, Table 3) was carried out.  $\delta$ -was increased, and a change in product moisture level was detected every 30 minutes (Fig. 1).

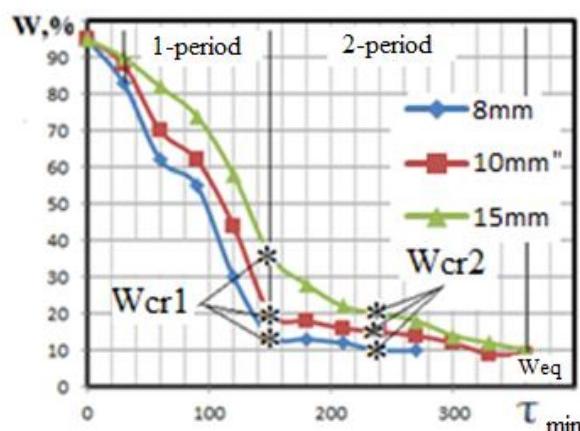


Figure 1. Drying curve

The results of the drying process of tomatoes of three different thicknesses show that during 15-20 minutes, i.e., during the heating of the product, a partial change in the moisture content of the product was observed, the moisture content of the 8 mm thick tomato fruit increased from 95 percent to 86 percent, and the moisture content of the 10 mm thick sample increased to 88 percent. the moisture content of the sample

with a thickness of 15 mm decreased to 91%. In the period of constant drying rate (period I), the acceleration of the rate of decrease of moisture content according to the straight line law was observed, and the period of decrease of moisture according to this law  $\omega_{cr1}^c$  continued until the first critical moisture point of the drying rate [20].

Table 1

Dry tooth time hour	Size (mm)	Dry dental process product in change in lot mass shi, (grams)	Dry matter in the product, %/ gr	Break up the amount of moisture that leaks outri, %	Moisture change of shi, %	Dry tooth is fastgi % / min	Product moisture storage of (kg.moisture / kg.dry matter)
0	8	1384	5.0÷5.3 / 69.2÷73.3	5	95		0.97
30	8	407	5.0÷5.3 / 69.2÷73.3	17	83	32.5	0.85
60	8	182	5.0÷5.3 / 69.2÷73.3	38	62	3.75	0.65
90	8	153	5.0÷5.3 / 69.2÷73.3	45	55	0.32	0.56
120	8	98	5.0÷5.3 / 69.2÷73.3	70	30	0.45	0.30
150	8	80	5.0÷5.3 / 69.2÷73.3	86	14	0.12	0.141
180	8	79	5.0÷5.3 / 69.2÷73.3	87	13	0.0055	0.130
210	8	78	5.0÷5.3 / 69.2÷73.3	88	12	0.0047	0.120
240	8	77	5.0÷5.3 / 69.2÷73.3	90	10	0.0041	0.10
270	8	76	5.0÷5.3 / 69.2÷73.3	92	8	0.0037	0.081

Table 2

Dry tooth time hour	Size (mm)	Dry dental process product in change in lot mass shi, (grams)	Dry matter in the product, %/ gr	Break up the amount of moisture that leaks outri, %	Moisture change of shi, %	Dry tooth is fastgi % / min	Product moisture storage of (kg.moisture / kg.dry matter)
0	10	1367	5.0÷5.3 / 69.2÷73.3	95			0.95
30	10	576	5.0÷5.3 / 69.2÷73.3	12	88	26.3	0.92
60	10	230	5.0÷5.3 / 69.2÷73.3	30	70	5.76	0.76
90	10	182	5.0÷5.3 / 69.2÷73.3	38	62	0.53	0.65
120	10	123	5.0÷5.3 / 69.2÷73.3	52	44	0.49	0.44
150	10	86	5.0÷5.3 / 69.2÷73.3	80	20	0.24	0.201
180	10	84	5.0÷5.3 / 69.2÷73.3	82	18	0.111	0.181
210	10	82	5.0÷5.3 / 69.2÷73.3	84	16	0.0095	0.161
240	10	81	5.0÷5.3 / 69.2÷73.3	85	15	0.0041	0.147
270	10	80	5.0÷5.3 / 69.2÷73.3	86	14	0.0037	0.141
300	10	79	5.0÷5.3 / 69.2÷73.3	88	12	0.0033	0.120
330	10	78	5.0÷5.3 / 69.2÷73.3	92	9	0.0030	0.090

Table 3

Dry tooth time hour	Size (mm)	Dry dental procedure nida mahsu change in lot mass, (grams)	Dry matter in the product, %/ gr	Break up the amount of moisture that leaks outri, %	Moisture change of shi, %	Dry tooth is fastgi % / min	Product moisture storage of (kg.moisture / kg.dry matter)
0	15	1052	5.0÷5.3 / 69.2÷73.3	95			0.98
30	15	692	5.0÷5.3 / 69.2÷73.3	10	90	12	0.92

60	15	384	5.0÷5.3 / 69.2÷73.3	18	82	5.13	0.82
90	15	266	5.0÷5.3 / 69.2÷73.3	26	74	1.31	0.152
120	15	164	5.0÷5.3 / 69.2÷73.3	42	58	0.85	0.64
150	15	108	5.0÷5.3 / 69.2÷73.3	64	36	0.373	0.360
180	15	96	5.0÷5.3 / 69.2÷73.3	72	28	0.0666	0.281
210	15	88	5.0÷5.3 / 69.2÷73.3	78	22	0.0380	0.220
240	15	86	5.0÷5.3 / 69.2÷73.3	80	20	0.00833	0.201
270	15	84	5.0÷5.3 / 69.2÷73.3	82	18	0.0074	0.180
300	15	82	5.0÷5.3 / 69.2÷73.3	86	14	0.0066	0.148
330	15	80	5.0÷5.3 / 69.2÷73.3	88	12	0.0060	0.120
360	15	78	5.0÷5.3 / 69.2÷73.3	90	10	0.0055	0.100

The curves obtained during the period of decreasing speed of drying (period II) take two different forms in a certain character and explain the second critical speed  $w_{cr2}^c$ . At the end of the second period, the product moisture asymptotically approaches the equilibrium moisture limit. Therefore, the equilibrium moisture limit in the drying cycle explains that the evaporation of moisture from the product composition is completely stopped.

During the drying process, the threshold values of the equilibrium humidity were analyzed, and  $10 \leq \varphi \leq 90\%$  the desorption process was studied at the relative humidity of air and the corresponding temperature  $25^{\circ}\text{C} \leq t \leq 62^{\circ}\text{C}$ . The obtained results show that the desorption isotherm of tomato fruit has a certain characteristic point at the above-mentioned limits of temperature and relative humidity of the air, among which the following quantities were determined according to the moisture content of the product in three sections of the drying kinetics [8,9,10,14]:

- monomolecular adsorption within the range of 0 ÷ 17% of relative air humidity;

- polymolecular adsorption from 15% to 30% relative air humidity;

- change of humidity in microcapillaries at the limit of 30% relative air humidity and above.

of the equilibrium function,  $y = f(W_{eq}, t, \varphi)$  the equilibrium moisture of the tomato fruit has the following form,

$$W_{eq} = K_1(t) + K_2(t) [\lg(\frac{1}{1-\varphi})]^{1/2}$$

(5)

Based on the results of the drying process speed curve (Fig. 2), the values of the drying process coefficients  $K_1$  and  $K_2$  were determined for the 2 sections of the desorption process,  $K_1 = 7.9 + 0.43t$ ;  $K_2 = 1.8 \cdot t^{0.169}$ . The obtained results confirm that 8 ÷ 12 % it is desirable to dry tomato fruit around [8,13].

The analysis of the curve of the drying process speed shows that during constant drying speed (I)  $w_{cr1}$ , 34-35% of the content of the tomato fruit with a thickness of 8 mm, 25-26% of the content of the tomato fruit with a thickness of 10 mm, and from the content of the tomato fruit with a thickness of 15 mm 14-15% moisture is released. In the period of decreasing drying rate (II),  $w_{cr2}$  the equilibrium moisture content of the tomato fruit with a thickness of 8 mm is 9%, the equilibrium moisture content of the sample with a thickness of 10 mm is 11%, and the equilibrium moisture content of the sample with a thickness of 15 mm is 12-13%. In this II period, the evaporation of moisture from the composition of the product slows down, the temperature of the product partially rises, and the  $w_M$  evaporation of moisture becomes zero when the moisture content of the product reaches the equilibrium state [19].

Density of heat capacity for the drying process of tomato fruit – g; the limits of influence of wavelength –  $\lambda$  and air speed were determined, and the duration of the drying process was calculated for the non-stationary regime  $V_{air}$ . When processing the results, a multifactorial experimental plan was drawn up and appropriate calculations were made using the

derivative square method [4,5,10]. Based on the full factorial experiment, equations representing the value of constant drying rate  $N$  for the first period of the kinetics of the drying process, the value of the drying coefficient  $K$  for the second period of drying, and the critical moisture change were obtained  $W_{cr}$  [15]:

$$N = 0.38 \exp (0.18g + 0.163 v_{air} + 0.072 t_{air} + 0.18\lambda)$$

$$K = 0.137 \cdot 10^{-2} \cdot \exp(0.601 \cdot g + \frac{2.3V_{air}}{18.65+7.36 \cdot V_{air}}) + 0.074 t_x + 0.178\lambda$$

$$W_{cr} = 468.77 \cdot \exp (-0.0179 \cdot v_{air} + 0.0079 t_{air} + 0.029\lambda)$$

$N$ ,  $K$  and  $W_{cr}$  correlation coefficients represent the adequacy of the tomato fruit drying process.

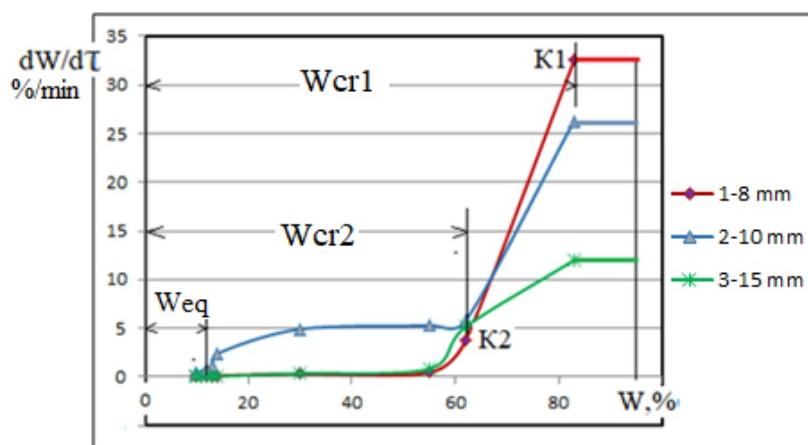


Figure 2. Drying process speed curve

## Figure 2. Drying process speed curve

Parameters influencing the drying process ( $g$ ,  $v$ ,  $t$ ,  $\lambda$ ) within the following limits ( $0 \leq g \leq 0,95 \text{ kW/m}^2$ ;  $1.5 \leq v_{air} \leq 2,2 \text{ m/s}$ ;  $58^\circ\text{C} \leq t_{air} \leq 62^\circ\text{C}$ ;  $0.7 \leq \lambda \leq 2,8 \text{ mkm}$ ) the deviation error of the performed calculations is 5%. The process slows down as a result of the initial direction of the drying process, i.e. through heat-moisture-conduction, liquid droplets in the product are directed toward the center. In the second period, the temperature gradient in the product decreases, and the movement of liquid drops begins to move in the opposite direction, that is, from the center to the evaporation zone (surface). As the temperature increases per unit of time, the release of moisture in the product accelerates. As a result, in the first period of the drying process, the drying speed increases by 3.5÷4 times, and the value of the drying coefficient 2,0÷2,5 increases by times.

During the period of constant drying rate of the drying process, the critical moisture content of the product 1,5÷1,8 was observed to decrease by 1.5 times, the rate of drying process was observed to increase by 1.5 times, and during the period of decreasing drying rate, it was observed to increase by 1.2 times.

A drying device was developed for processing tomato fruit based on pulse mode and drying at low temperature in the wavelength range of 0.7÷1.1 and 2.4÷2.8  $\mu\text{m}$  of infrared light. In the drying device, it was possible to control and adjust the change of parameters such as product humidity, temperature, relative humidity of the air in the drying chamber by units of time, and to implement the technological process based on the automatic control system [9,11,18].

**Discussions.** The theoretical and practical experiments conducted on the drying process show that the efficiency

level of the production of dried fruits and vegetables is evaluated by the energy efficiency of the device, the quality index of the finished product, and the shelf life. The most important factor affecting these indicators is the process of heat treatment of this product, and it is appropriate to develop an optimal design of the drying device on this basis . Traditional drying methods for the production of dried agricultural products are no longer suitable for low-productivity industries due to their high energy costs. Because a number of drying equipment is designed to work on the basis of liquid and gaseous fuels. Due to the rapid increase in the world price of such energy resources, the cost of the produced products is sharply high and does not cover the expenses. From this point of view, the application of optimal options of heat exposure based on the non-traditional heat treatment method and accelerating the movement of moisture in the product to the surface - in a step-by-step, pulse mode, creates the basis for obtaining targeted results [12].

**Conclusion**. The conclusion is that in the initial stage of the drying process (50-60 minutes of the period of heating and drying speed of the product) in order to accelerate the molecular movement of liquid droplets in the product, to generate the required heat for the release of moisture, the wave of infrared  $\lambda = 0.7 \div 1.1 \text{ mkm}$  light based on the implementation of processing based on the pulse mode in the length range. Then, in the period of decreasing drying speed (II), as well as the continuous  $\lambda = 2.4 \div 2.8 \text{ mkm}$  drying process in the wavelength range of infrared light up to the equilibrium moisture limit of tomato fruit, created the basis for obtaining a positive result. The advantage of continuous drying in the infrared wavelength range is that liquid droplets located in the center of the product have maximum absorption at this wavelength, which accelerates the movement of moisture to the surface  $\lambda = 2.4 \div 2.8 \text{ mkm}$ .

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## OIL EXTRACTION STUDIES FROM FLAX SEEDS

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**Abstract.** The article conducted an experiment on drying, that is, heat treatment, laboratory conditions, provided information about the process for obtaining oil from flax seeds. At different drying temperatures, the properties of the oil release are described in detail, the degree of moisture release at intervals and the degree of oil release at different drying times are determined. The main indicators that determine the production of linseed oil are the drying temperature and drying time. In the heat treatment process (80-150°C), the duration of the process was set at 5 to 60 minutes.

**Keywords:** linseed oil, heat treatment, drying, oil content, pressing, extraction.

**Introduction.** Today, the development of new technologies and the introduction of domestic raw materials into production is of great importance. Flaxseed (*Linum usitatissimum*) is the product of most interest to food industry researchers due to a number of functional compounds in its composition. The most important thing is that flaxseed contains a concentrated amount of lignans that cannot be taken together with flaxseed oil [1].

Lignans are considered plant Garmon with a potential protective effect, and the positive effect in the treatment of cardiovascular diseases, cancer and diabetes is inconsistent [2].

Flaxseed oil is made from ground and squeezed flaxseed. It is available in capsules and liquid form. It contains omega-3 fatty acids, which are important for physical and mental health. And alpha-linolenic acid in combination with other chemicals can have a positive effect on inflammation. Cold pressed flaxseed oil clear it has a characteristic aroma, golden-yellow color, slightly bitter in taste. Flaxseed oil has one drawback. Its fatty acids oxidize quickly, so it must be kept away from air and light.

Vegetable oils are produced in pressing, forpress-extraction, direct extraction methods. The pressing method also has oil extraction technology in single-

stage pressing, two-stage pressing, and cold pressing methods. It should also be borne in mind that the method of obtaining oil, the method of obtaining oil and technological processes are lubricated it gives a good effect when applied according to the structure of the raw material. Currently, non-traditional oil raw materials (flax, sesame, rapeseed, sedana, etc.) requires extraction by the cold pressing method. Because this method leads to the preservation of biologically active substances contained in oilseed, as we know With thermal processing at high temperatures, oil from seed causes a significant loss of vitamins when oil is produced. Processing sesame and flax seeds requires mechanical processing.

Methods of obtaining oil have been analyzed, it can be said that technological processes such as mechanical exposure to oil raw materials and thermal processing, even short-term processing, lead to changes in the composition of raw materials, especially in the oil phase [3].

When obtaining oil from fatty raw materials, processing them at low temperatures leads to the preservation of biologically active substances in the product. When up to 20% of the starch contained in the seeds is heated, it passes into dextrins, which are easily absorbed by the human body, and toxic substances are

lost. When the temperature rises, the protein undergoes denaturation when the temperature is 50-130 °C, the vitamin complex is almost completely preserved when treated at short time. Thus, the effect of heat treatment helps to increase the digestion of nutrients by 20-25%. The composition of linseed oil is unique. In particular, such components as Omega-3, which are characteristic of the human body, are even more than the amount in fish oil in it. In no product, the Omega-3 mixture is at this level not much. In addition, flaxseed oil also contains other fatty acids. Such a combination of these substances increases the more uniqueness and usefulness of the oil. In addition to fatty acids, this vegetable oil is also rich in vitamins. These are vitamins A, E, B and K. This oil helps to remove toxins from the liver from the body. Flaxseed contains an antioxidant that destroys nitrates (for example, in consumed fruits and vegetables) [4].

Flaxseed oil is a dietbop moh in terms of its composition and is widely used in medicine, in the food industry. Flaxseed oil contains a large amount of omega-3 unsaturated fatty acids, which are about one times more than those contained in fish oil. Also, flaxseed oil has a high nutritional value, it increases the activity of the immune system of the human body,

stimulates the activity of the brain and other organs [5].

Referring to the content of flaxseed, the nutrients that have the main value are: fatty acids such as stearin (8-9%), olein (15-20%), linol (25-35%), linolene (35-45%) and also fatty acids such as (18-33%) proteins, (12-26%) carbohydrates [6].

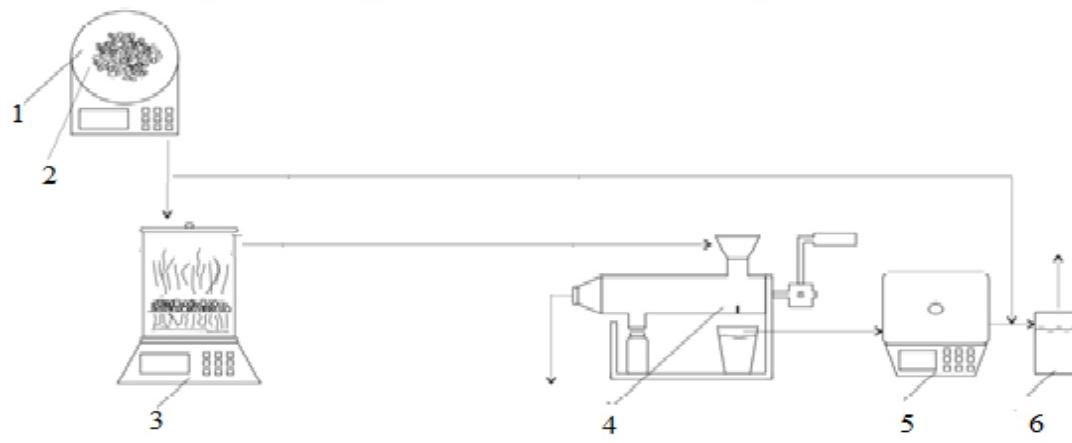
**Materials and methods:** Research was carried out on flax seeds of the Bakhmalski-2 Variety with an oil content of 38.10%. The results of the experimental test were fully comparative analyzed [7-8].

The oiliness of seeds is understood as the amount of oil in them, the composition of the raw materials and the accompanying fatty substances, when oil is produced by the extraction method, the oil is transferred to the composition of the accompanying substances in the raw materials.

Vegetable oils contain a certain amount of free fatty acids, which depend on the quality of the oil. The presence of free fatty acids worsens the quality of fat, reduces its nutritional value.

The acid number of the oil used for food should not exceed 0.20-0.30 mg KOH. And from this comes the need to lose fatty acids, so that the method of determining the number of acids is carried out [9].

### Laboratory technological scheme for obtaining oil from flax seeds



1-scales, 2-flaxseed, 3-drying cabinet, 4-maslo press, 5-scales, 6-pure oil

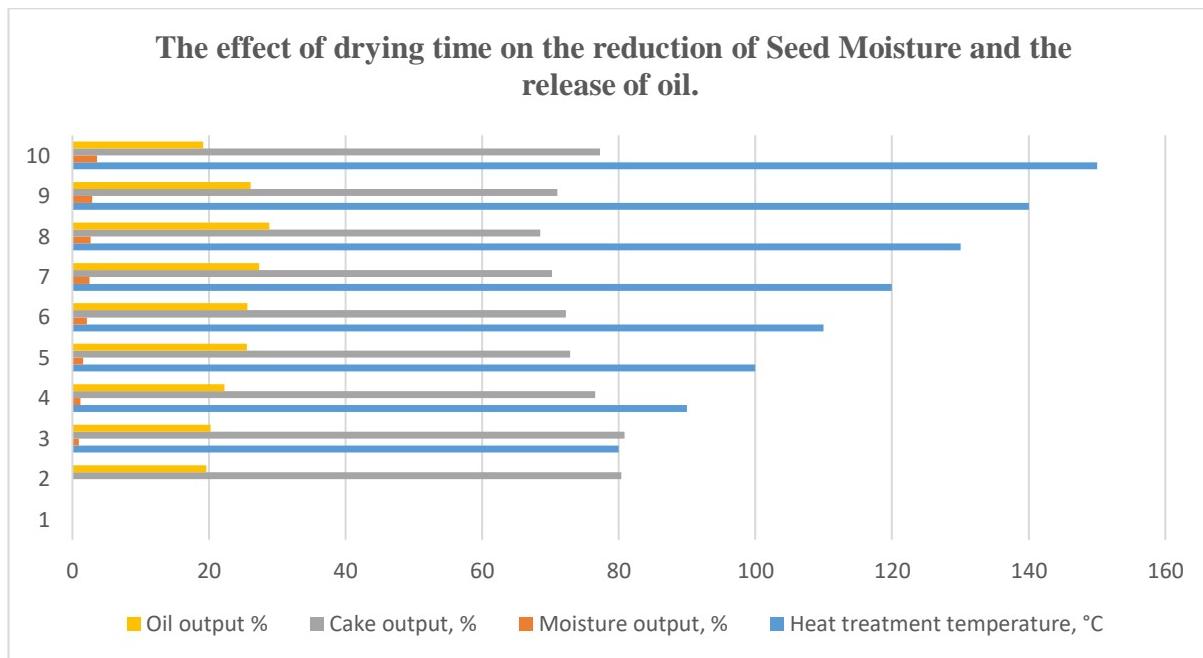
**Results and discussion.** The effect of heat treatment on the output of linseed oil.

On the technology of obtaining oil by heat treatment of flax seeds, several experiments were carried out. As we know, in the oil production industry, oil raw materials are extracted from mixtures, cleaned and ground in a Valsalva, fried in a frying pan and then pressed oil at a temperature of 110-130 °C. And we carried out experimental tests of oil extraction from flax seeds on a laboratory device. In this

case, we treated the peeled flax seeds directly with heat without forming a grater, choosing the temperature to 80-150 °C. The timing of the processing process was selected for 30 minutes.

Studies of the heat treatment process showed a decrease in Seed Moisture by 0.92% at 80 °C, 1.60% at 100 °C, and 2.66% at 130 °C when selected for 30 minutes.

The Optimal heat treatment jar was set to a temperature of 130 °C and a heat treatment duration of 30 minutes.

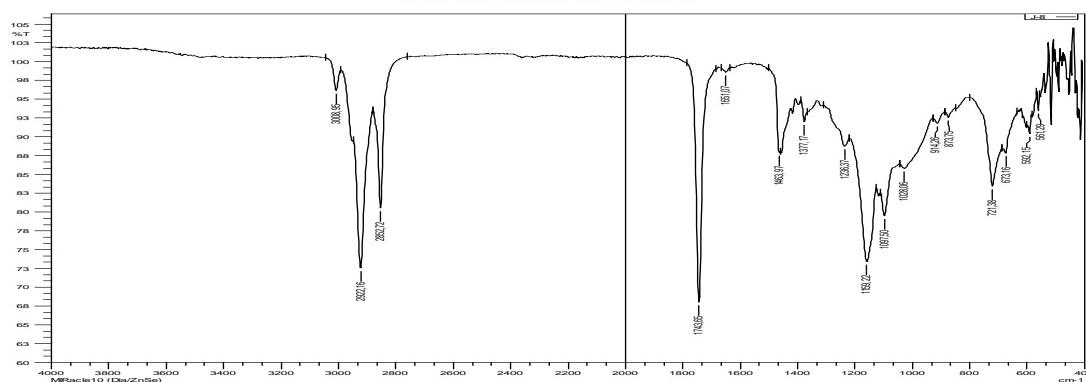


**Fig. 1.1. The effect of temperature on the release of linseed oil during 30 minutes of heat treatment**

In Figure 1, oil was produced from flax seeds with an oil content of 38.10%, in which the effect of temperature on the output of linseed oil during 30 minutes of heat treatment was studied the effect of temperature on the output of linseed oil at

a temperature of 130 °C on flax seeds, as can be seen in the table. The result of the experiments showed that the process of obtaining oil by processing flax seeds at a temperature of 130 °C for 30 minutes was perceived as optimal.

## Results of analysis of IQ spectroscopy analysis of flaxseed oil obtained in the current method



In the IQ-spectroscopy of the resulting compound, free carbon wadorode bonds (=C-H) with absorption bands are visible in the 3008 cm<sup>-1</sup> Area. And in areas 2922-2852 cm<sup>-1</sup>, there is a high absorption band of methylene (CH<sub>2</sub>) groups. In a very intensive area of 1743 cm<sup>-1</sup>, a carbonyl (C=O) group band is visible. 1463 cm<sup>-1</sup> methyl (CH<sub>3</sub>) groups are present in the field. 1377 cm<sup>-1</sup> nitrate ion intensive Bonds (No. 3) are visible. There are 1236 cm<sup>-1</sup> phosphorus oxygen (R=O) intensive bonds. 1159 cm<sup>-1</sup> phosphorus oxygen and carbon (-P-O-C-) bonds are visible. There are 1097 cm<sup>-1</sup> perchloride (ClO<sub>4</sub><sup>-</sup>)

functional groups. There are 873 cm<sup>-1</sup> deoxy (-O-O-) groups.

**Conclusions.** Thus, studies conducted in preparation for the production of oil from flax seeds, obtaining linseed oil using heat treatment, provide an opportunity to increase the level of oil output. To do this, the drying process was carried out at a temperature of 80-130°C, and the alternative drying temperature was determined at 130 °C and the drying time was 30 minutes. The results of IQ spectroscopy analysis of flax seed oil were also cited in this article.

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## IMPORTANCE OF POTATO POWDER EXTRACTION TECHNOLOGY IN PRODUCTION AND INDUSTRY

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### Abstract:

**Objective.** Potatoes were originally used as food by South American Indians. Its cultivation began about ten thousand years ago in the territory of Peru. Information about potatoes reached Europe only in the 16th century, and it was widely used in cooking from the 18th century. Currently, potatoes are grown in all regions of the world. It has about 4000 species. Russia, Belarus, Ireland and China are the countries where potatoes are consumed the most. At first, potatoes were used as a houseplant and planted in flower pots to decorate the house.

**Methods.** In our research work, a technological line for drying and juicing potatoes from nodular products in the belt drying chamber of a convective drying device.

**Keywords.** solanine, technical, puree, starch, phenanthrene derivative, amino acid, vitamin, diseases, extract, juice, convective drying device, potato juice.

**Introduction.** Potato is a vegetable that was imported from the sea and was brought to Europe from South America in the middle of the 17th century. Potatoes contain many types of trace elements, B group and vitamins A, C, U, PP group, potassium, zinc and magnesium, calcium. It contains carbohydrates, iron, phosphorus, and iodine elements. Due to its starch content, it gives energy to the

body and is extremely satiating. Potato nodules contain starch (about 20 proteins, sugar) and other substances. Alcohol, starch and glucose are obtained from them.

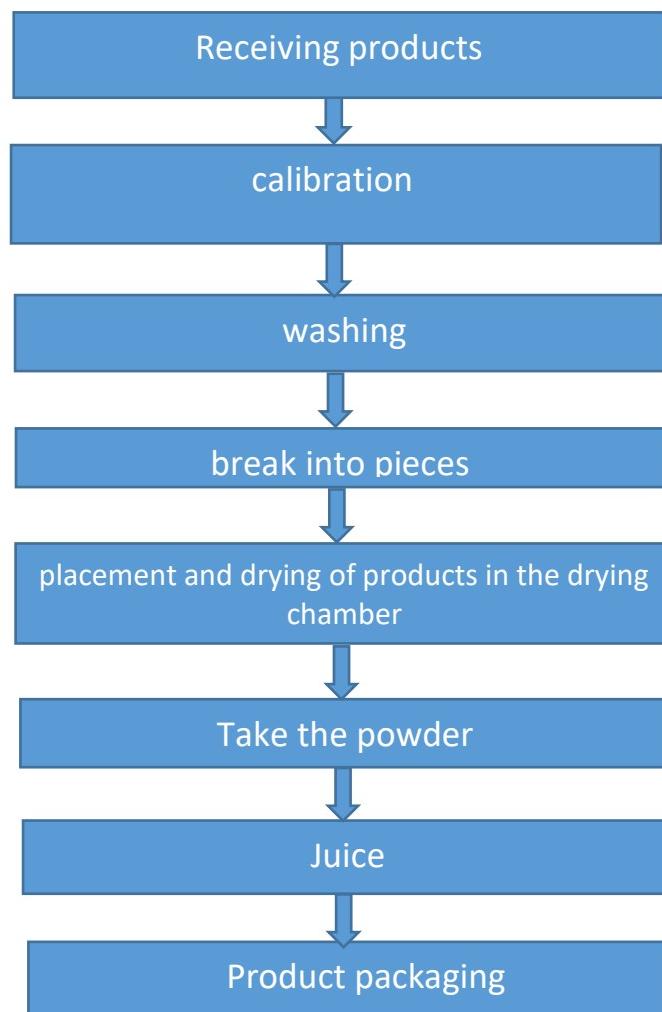
It is known that the demand for dried fruits and vegetables in our country is increasing year by year. That is, the production of high-quality, low-cost products with high food value and innovative energy-saving high sublimation

and convective drying technologies are widely used in the food industry today, is being used.

**Results.** To process product samples in a solution of ascorbic and citric acids for 5 minutes, a solution is prepared by adding 20 mg of ascorbic acid to 250 ml of water, and the potato samples are processed by soaking them for several minutes. They are placed in a test tube and then dried in a drying chamber on 4 tapes for 2 hours. The total drying period was 30 minutes at 80 °C on tape 1, 25 minutes at 75°C on tape 2, 35 minutes at 90°C on tape 3 and finally on tape 4 for 20 minutes at 80°C. The total drying period lasted 2.5-3 hours, and it was achieved that the total organoleptic indicators of the product samples were preserved according to the standard. The main goal of processing the potato samples

with ascorbic acid and citric acid was achieved with consistency (shape). Since potatoes contain a lot of starch, the product darkens quickly. Potato products selected for drying are products rich in vitamins and minerals according to the standard. During the drying period, we cut potatoes into pieces of different sizes, mainly 3-5 mm in size, depending on the type of product and their size. Potato tubers contain 75-80% water, 23.7% dry matter, including 17.5% starch, 1-2% protein, 0.5% sugar, 1% mineral salts, as well as vitamins V, V2, V6, C, RR, D vitamins and provitamin A (carotene), and the skin contains a poisonous substance - solonin. Potatoes play an important role in people's diet. According to physiological recommendations, the annual potato consumption per person is 45 kg.

### Potato powder and juice extraction technology



Chemical composition			
B6-15%	Si-16.7%		
S-22.2%	Co-50%		
K-22.7%	Cu-14%	Mo-11.4%	

**Discussions.** Solanine- is found in some vegetables (tomatoes and eggplants) and potatoes. The chemical composition of solanine in different vegetables is different. Solanine accumulates in the skin and the layer close to it and gives it a taste. Potato solanine ( $C_{45}H_{71}NO_{15}$ ) contains sugars, rhamnose, galactose, Aglyconsolanidin ( $C_{14}H_{10}$ ) is a group of trinuclear aromatic compounds derived from glucose and phenanthrene.

Varieties of potatoes, depending on what they are intended for, are conventionally divided into khoraki, technical, hashaki and universal varieties.

Among the people, potato is also called "second bread". It is distinguished from other crops not only by its nutritious properties, but also by its healing properties. It participates in the conversion of amino acids, tryptophan, lipids and nucleic acids in the metabolic process. Potatoes also contain antioxidants and phytonutrients that are important for the body.

Vitamin B6 contributes to the production of "hormones of happiness" (dopamine, serotonin, norepinephrine), helps fight stress, bad mood, improves brain activity.

Vitamin C is an antioxidant that protects the body from free radicals, increases immunity and resistance to various diseases.

Potassium supports the nervous system, muscle activity, regulates blood pressure.

**Potato extract.** Potato extract is mainly obtained from potato tubers. Potato is also known as potato, sun taro, yam egg, sweet potato, artichoke, mashed egg, Dutch potato, sweet potato size, etc. It is rich in protein, fiber and carbohydrates. provides a large amount of nutrients for the

human body. Potato, which is the main compound of potatoes, effectively prevents the accumulation of fat in the cardiovascular system, maintains the stability of blood vessels, prevents atherosclerosis, protects the liver, kidneys, heart and other organs. and develops the respiratory system. Potatoes are low in calories and have a strong feeling of satiety. This is a high-quality coarse grain product, a good product for those who lose weight and are healthy, as well as middle-aged and elderly people. is a good health product for people.

Potato extract vitamins are rich in microelements such as proteins, carbohydrates, calcium and potassium, easily digested and absorbed by the body, and provide a lot of nutrients and energy for the body.

Keto potato extract contains many protein and vitamin groups, they warm the stomach, stimulate gastrointestinal motility, accelerate the digestive function of the spleen and stomach. Potatoes are rich in dietary fiber, which helps defecation and prevents constipation. and cures various intestinal diseases. Potato powder can provide the human body with a large amount of mucin, which keeps the digestive tract, respiratory tract and joints lubricated, and prevents cardiovascular fat accumulation. prevent, maintain blood circulation and prevent arteriosclerosis. The potassium in potatoes can accelerate the excretion of excess sodium in the body and has a clear healing effect on patients with hypertension, nephritis and edema. Potato extract is rich in dietary fiber and protein and low in calories. and has a strong satiety, which provides sufficient nutrition for the body and is a good product for weight loss. Potato protein powder can regulate the immune function, provide various amino acids, accelerate

metabolism and provide the body with new tissue cells. Potato protein powder is useful for lowering plasma cholesterol levels and helps patients with high cholesterol levels to recover faster.

**Potato juices.** Many people do not know that fresh potato juice is less useful than the root. The composition of the drink contains about 30 different useful elements. the drink has a high concentration of ascorbic acid, tocopherol,

nicotinic acid, vitamins of group B, they not only strengthen the body's defenses, but also remove products that release toxins from heavy metal salts. Doctors recommend drinking water to people suffering from gastrointestinal diseases, including hypertensive patients with peptic ulcers. Due to its analgesic and antiseptic properties, drinking water helps to quickly heal injuries and inflammation.



**Figure 1. Samples of received products**

**Conclusion.** The purpose of our study of these technologies is mainly to obtain waste-free products, to avoid excessive wastage, to produce primary and secondary products. Through these drying

methods, we can store products for a long time. However, the color, shape and size of the product samples are different. changes are observed.

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## CHEMICAL TECHNOLOGIES

# RESEARCH OF CORROSION AND FOAMING PROCESSES IN GAS ABSORPTION PURIFICATION AND TECHNOLOGY OF THEIR PROTECTION IN INHIBITORS

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### Abstract:

**Objective.** The article presents the results of scientific studies of corrosion inhibitors synthesized on the basis of local raw materials in technological devices and information about the technological processes of inhibition. The adsorption and mechanism of action of the synthesized corrosion inhibitor TFO on metals were studied. Based on the results of the study, a technological scheme for the use of the corrosion inhibitor TFO in the technological devices of the Gazli Gas Processing Plant was recommended in order to sharply slow down corrosion.

**Methods.** Corrosion studies were carried out by gravimetric method in different metal brands and in different environments.

**Results.** The synthesized TFO corrosion inhibitor showed 93.8% protection efficiency at 100 mg/l at different concentrations.

**Conclusion.** The inhibitor formed a very thin layer on the metal surface and created conditions for its protection against corrosion in the external environment.

**Keywords:** corrosion, amine, absorption, adsorption, foaming, solution, absorbent, inhibitor, protection efficiency.

**Introduction.** At present, corrosion and foaming of devices and equipment are considered to be a problem in the purification of hydrocarbon raw materials from sour components of gas processing plants.

The mechanism of corrosion in gas cleaning devices with amines is very complex. At high temperatures, metallic iron reacts with carbonic acid to form water-soluble iron bicarbonate. During CO<sub>2</sub> desorption in the regenerator, iron bicarbonate turns into insoluble iron carbonate, which settles on the device and pipe walls.

In the investigated studies, it was found that the heat exchange devices, ie boiler, condenser, regenerator, heater, coolers and throttle valves are exposed to the strongest corrosion.

One of the most effective ways to combat metal corrosion is to form a corrosion-resistant thin layer. For this, it is necessary to circulate the system with a stream of heated 0.5% aqueous solution of MEA for a long time. In addition, corrosion inhibitors can be used to slow down corrosion.

Corrosion cracking is the most common type of corrosion of technological devices during the amine gas purification

process. One of the main reasons for this is the efficiency of saturation of amine solutions with sour component gases, high temperature, mechanical impurities, decomposition of amines and an increase in amine concentration.

**Methods.** Metal 09Г2С steel plate, 20% aqueous solution of HCl and synthesized TFO corrosion inhibitor were used in the study. The composition (%) of the 09Г2С steel plate sample is given. In this, Fe=96-97; Si=0.5-0.8; Cr=0.3; Cu=0.3; Ni=0.3; As=0.08; Mn=1.3-1.7; S=0.04; P=0.035; N=0.008; C=0.12.

In the research work, first, steel plates were prepared in the size of 20x40x4mm

(20 cm<sup>2</sup>) and thoroughly cleaned with 100x100 mm sandpaper. Then it was washed several times in distilled water and acetone and then dried.

Determining the rate of corrosion, the effect of concentration and temperature on the effectiveness of the corrosion inhibitor was studied by finding the mass change by the gravimetric method according to GOST 9.905-82.

Table 1 shows the results of testing samples of various steel brands in the saturation of 0.7-0.8 mol of sour component gases per 1 mol of amine solution.[1,2]

Table 1

**Corrosion rate (mm/year) of various steel and alloy samples placed in the equipment and equipment for gas absorption treatment**

Sample device (ambient temperature and pressure)	Carbon steel	Steel grade and alloy					
		X5M	X8	08X13	08X22H6 T	X18H10T	X17H13M2T
Desorber, under a closed plate; 120 °C; 0.15 MPa.	0.12	-	0.08	0.11	0.0006	0.0005	0.0001
Under the desorber chamber; 120 °C; 0.15 MPa.	0.11	-	0.06	0.007	0.00017	0.00018	0.00018
Boiler, upper part of the device; 115-120 °C; 0.15 MPa.	0.057	-	0.01 2	0.0003	0.0006	0.0008	0.0007
The lower part of the absorber; 40 °C; 5.6 MPa.	0.0057	-	0.00 1	0.008	0.0015	0.00006	0.000057
The part of the space between the refrigerator-condenser pipes; 115 °C; 0.15 MPa.	0.01	0.00 29	0.00 2	0.0003 8	0.00021	0.000063	0.00019
Refrigerant-condenser tube cavity; 45 °C; 0.15 MPa.	0.21	0.13	0.03 9	0.001	0.00005	0.0002	0.00034

When testing devices of various steel brands in the environment of amine solutions, it can be seen that the samples in the desorber are the most corroded. It is possible to see the types of uneven, wound, pitting corrosion. The rate of corrosion caused by sour component gases in the refrigerator-condenser does not exceed 0.01 mm/year for carbon steels (except for X5M and X8).

According to Table 1, it can be seen that the devices and equipment at the "Gas Gas Processing" plant are exposed to strong corrosion due to the acid component gases. Local corrosion damage in the form of pits was manifested in the steel stamps of the absorber and desorber devices.

Corrosion of devices and equipment for cleaning gases from sulfur compounds in gas processing plants, increase of saturation efficiency of amine solutions

from compounds with acidic components up to 0.8 mol/mol, as well as local damage (pitting) corrosion efficiency due to the presence of chlorides and other impurities in amine solutions It was 0.6 mm/year.

**Results.** In Table 2, the change in the inhibitory effect of inhibitors at a temperature of 60 °C was studied using different inhibitors.

Table 2

**Variation of inhibition efficiency with respect to water hardness for different inhibitors (temperature t=60 °C)**

Inhibitor concentration, mg/l	Inhibition efficiency, %		
	Water hardness, mg eq/l 4–6	7 – 9	10 – 12
<b>INKORGAZ-11TNT</b>			
20	81.5	81.7	69.4
50	81.9	82.2	70.0
80	82.6	83.5	70.8
100	90.5	91.3	71.1
200	92.2	93	72.6
Oligomer based on thiosemicarbazide and formalin			
20	83	81.2	68.5
50	85	83.1	77.8
80	87	86.8	79.0
100	90.2	89.7	83.8
200	91.5	90.7	88.3
Modified oligomer based on thiosemicarbazide, formalin and orthophosphate (TFO)			
20	87.8	83.8	82.1
50	89.3	85.3	83.5
80	90.4	87.3	85.7
100	93.8	90.9	89
200	94.6	92.4	91.5

According to the results of Table 2, when compared with corrosion inhibitors obtained by synthesis and INKORGAZ-11TNT inhibitor produced abroad (a composition based on imidazolines and amidoamines, triethylenetetramine (TETA) obtained from a mixture of naphthenes and ethylhexane acids), the most effective TFO (thiosemicarbazide, formaldehyde and orthophosphate) is a corrosion inhibitor, the protection efficiency increases up to 94.6% with increasing concentration, the protection efficiency was 91.5% when the water hardness was 10-12 mg eq/l. Also, as water hardness increases, protection decreases to a certain extent, which

indicates that it forms a complex with metal ions contained in hard water. [3,4,5]

We can see that the protection efficiency increases with increasing concentration of TFO inhibitor. Over time, a stable layer of inhibitor molecules adsorbed on the metal surface is formed. The fact that the polarization resistance of the steel electrode does not change over time makes us come to this conclusion.

According to the analyzes of the Central Testing Laboratory of the Gazly Gas Processing Plant, the presence of salts in the saturated MDEA solution causes corrosion of the metal structures of the gas absorption gas purification plant and its technological branches. Table 3

shows the analysis results of methyldiethanolamine solution at Gazli gas processing plant.

**Table 2  
Analytical results of methyldiethanolamine solution at Gazli gas processing plant**

Units	Regenerated solution (MDEA)				Saturated solution (MDEA)				pH
	Conc. C%	CO <sub>2</sub> Mole/mole	H <sub>2</sub> S Mole/mole	Conc. C%	CO <sub>2</sub> Mole/mole	H <sub>2</sub> S Mole/mole	A mechanical particle. mg		
1	9.5	0.05	0.02	9.3	0.27	0.03	0.007	8.2	
2	33.8	0.04	0.06	33.4	0.27	0.12	0.007	8.3	
3	7.1	0.03	0.02	6.9	0.51	0.02	0.003	7.9	
4	33.8	0.01	0.06	33.4	0.27	0.12	0.004	8.0	
5	33.1	0.01	0.05	32.7	0.28	0.09	0.007	8.4	
6	40	0.02	0.01	39.5	0.17	0.11	0.004	7.8	

To reduce corrosion caused by salts in technological networks, it is advisable to carry out the following actions:

- based on the practice of using amine devices using MDEA, the concentration of regenerated MDEA solution should be increased to 30-35% in order to comply with regulatory values;
- control valves should be installed to continuously monitor and control the liquid level in the separators.

This prevents the ingress of hydrocarbon condensate and formation water into the absorbers, which prevents foaming, salt intrusion into the MDEA, and

accordingly reduces the loss of the MDEA solution.

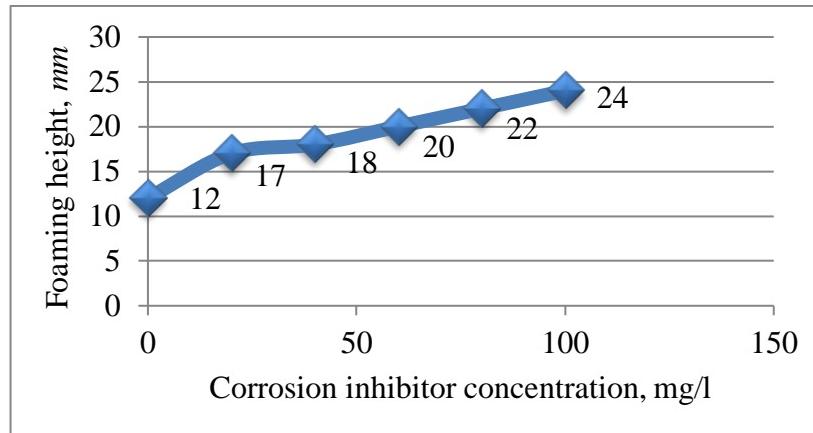
In the technological process, it is necessary to keep the temperature of the regenerated solution at a low level, and at the same time, it is necessary to maintain a temperature difference of 10÷15 °C between the raw gas and the regenerated solution before transferring it to the absorber. Otherwise, foaming of the absorbent may occur.

In order to avoid foaming when TFO corrosion inhibitor is mixed with MDEA solution, research works were conducted based on the standard approved in TU 2423-178-0020 3335-2007.

**Table 4  
Foaming performance of MDEA solution**

Foam height, mm	Foaming ability
less than 25	Low
25–60	Average
More than 60	High
Foaming time, seconds	Foam stability
less than 15	Low
15–60	Average
More than 60	High

Research work was carried out to determine the foaming ability of the mixture of MDEA and TFO corrosion inhibitor. The graph of dependence of the concentration of corrosion inhibitor on the height of foaming is presented in graph 1.



**Graph 1. Graph of dependence of corrosion inhibitor concentration on foaming height**

It can be seen in the graph that the foaming height was 17 mm when the inhibitor concentration was 20 mg/l, and 24 mm at 100 mg/l. This means that the MDEA solution has a low foaming capacity by foaming process index standards and indicates that the TFO corrosion inhibitor is not prone to foaming [5,6].

In addition, the presence of contaminants in the water pumped into the system can cause blockages in the system and many problems in operation.

If steam condensate without heat-resistant salts is used in the process, foaming, corrosion, clogging of evaporator pipes, clogging of pumps, formation of a layer of heat-resistant salts, subsequent reduction of heat exchange efficiency in the evaporator, and overall reduction in amine

It is necessary to avoid problems such as a decrease in conductivity.

It is known from many years of work practice that water without additives and thermally unstable salts is the most suitable for supplying water to reliable devices.

Research work was carried out to determine the corrosion rate of various absorbents (amines) by gravimetric method, i.e. according to GOST 9.905-82. Researches were carried out for 168 hours at a temperature of 120 °C and a value of 0.26 mole/mole of amine saturation with sour components based on Table 5.

Corrosion rates of 09Г2С steel in MDEA solution saturated with acidic components and in various anticorrosive solutions can be seen in Table 6 below.

**Table 5**  
**Corrosion rate of MDEA solution saturated with acidic components and various anticorrosive solutions on 09Г2С steel**

Solutions	Corrosion rate, mm/year
30 % DEA	0,0920
30 % DEA + 10 % PME	0,0967
30 % DEA + 2 % PP	0,0081
40 % MDEA	0,0962
40 % MDEA + 10 % PME	0,0884
40 % MDEA + 2 % PP	0,0091
40 % (MDEA / DEA – 50/50 %)	0,0998
40 % (MDEA/ DEA -50/50 %) +2 % PP	0,0017
40 % MDEA + 0,1 % TFO	0,0078

Based on the determined analytical results, as the temperature rises in amine

solutions saturated with sour components, as a result of the increase in the rate of

corrosion, corrosion cracking, i.e., pitting and wound corrosion occurs. The research showed that the corrosion rate increased when the amine solution was mixed with oxygen.

If oxygen is mixed in the amine solution, thiosulfate is present, and if carbon dioxide is present, aminoacetic acids and other types of acids are formed, which, together with reducing the property of absorbing acidic components of amine solutions, sharply increases the corrosive activity of the environment.

Research data shows that adding 10% PME (polyethylene glycol methyl ethers) to DEA and MDEA solutions reduced the corrosion rate of 09Г2С carbon steel by 10-12%. Piperazine (C<sub>4</sub>H<sub>10</sub>N<sub>2</sub>) had a more significant protective effect when mixed with an amine solution. Corrosion resistance of steel with 2% addition of piperazine (PP) to 40% DEA and 40% MDEA solution shows that the corrosion resistance of the steel

corresponds to the very durable score according to the graph approved by GOST 13819-68.

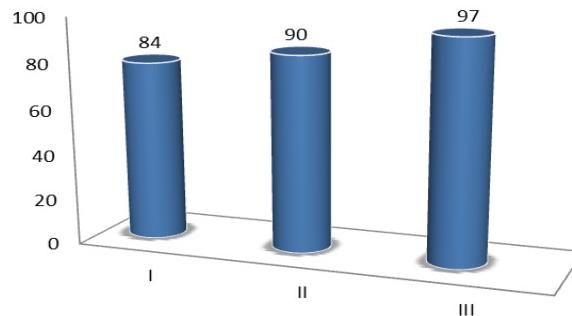
Vertical and horizontal separators, separators, ventilators, evaporators and tanks are made from 20 ІОЧ steel at the Gazli gas processing plant, and filters, separators for separating sour gases, from 09Г2С steel are made in some departments. desorbers, heat exchangers and coolers were prepared, and absorbers, desorbers, heat exchangers and coolers were manufactured from 12Х18Н10Т (GOST 5949-75) steel. During the studies, according to the gravimetric method of determining the protective ability of TFO corrosion inhibitor, it was observed that the corrosion rate (at 130 °C) is much higher in 20 ІОЧ and 09Г2С steels than in 12Х18Н10Т steel. The main reason for this is the non-alloying of steel grades and the presence of acidic components in the devices.

Table 6

**Alloy composition of different steel brands**

Steel brand	Composition of the alloy, %															
	S	Mn	P	S	Ni	N	As	Fe	Ca	Si	Sr	V	Cu	Mo	Ti	W
20 ІОЧ	< 0,12	0,16 - 0,22	0,5 - 0,8	< 0,02	< 0,005	< 0,25	< 0,08	97 - 98	0,001 - 0,010	0,17 - 0,37	-	-	-	-	-	-
09Г2С	< 2	1,3 - 1,7	< 0,03	< 0,035	< 0,02	< 0,3	-	96 - 97	-	0,5 - 0,8	< 0,3	< 0,12	< 0,3	< 0,4	< 0,8	< 0,2
12Х18Н10Т	< 0,12	< 0,035	< 0,02	9 - 11	-	-	63 - 65	-	< 0,8	17 - 19	< 0,2	< 0,4	< 0,5	< 0,8	< 0,2	

In order to reliably determine the corrosion rate at the Gazli gas processing plant, research work was carried out on 20ІОЧ, 09Г2С and 12Х18Н10Т steels.



**Figure 1. The graph of the efficiency of protection of different brands of steel at a temperature of 130 °C**

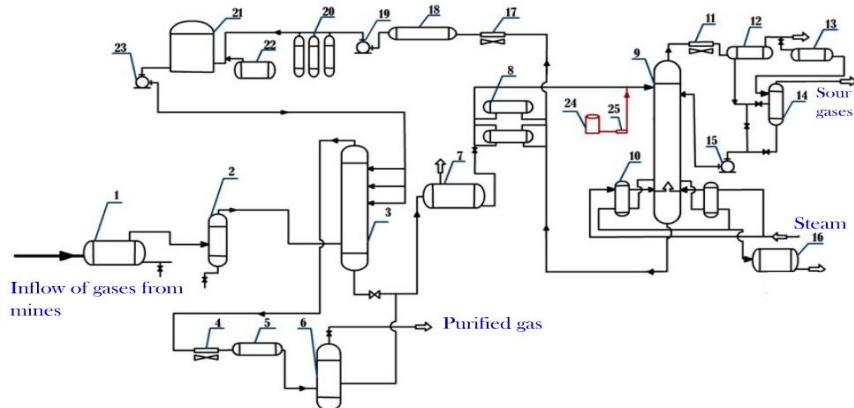
I – 20Ю4 brand steel; II – 09Г2С brand steel; III - 12Х18Н10Т brand steel

According to the results determined in the research, 12Х18Н10Т brand steel is the most corrosion-resistant, and the efficiency of corrosion protection is 97% (Fig. 1). In order to protect the technological devices at the Gazli gas reprocessing plant from various aggressive environments, the feasibility of using 12Х18Н10Т steel to increase their service life has been proven in research.

Based on the results of the research, a technological scheme was developed for the use of TFO corrosion inhibitor in technological devices in order to dramatically slow down corrosion at the Gazli gas recycling plant (Fig. 2).

Proposed TFO Corrosion Inhibitor In order to reduce the rate of corrosion occurring in the process lines during gas cleaning at the Gazli Gas Reprocessing Plant, MDEA's flow process scheme has added capacity for additional TFO corrosion inhibitor.

In the technological scheme, since the main center of corrosion is the desorber 4, the TFO corrosion inhibitor 2 with the saturated MDEA solution, which must be regenerated in the reboiler 5, is pumped into the desorber through the diaphragm pump 3. Taking into account the volume of MDEA solution in technological industries, it is advisable to use a corrosion inhibitor with a concentration of 0.1%.

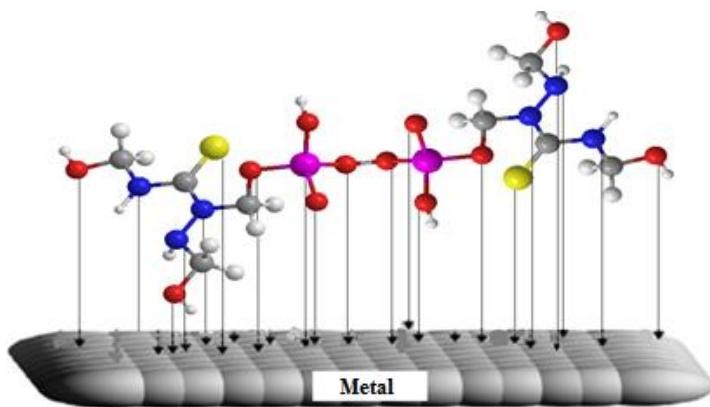


**Figure 3. The principle scheme of absorption of sour components of gases in Gazli gas processing plant and inhibition of saturated absorbent desorption system**

1, 2, 5, 6, 7, 12, 14 – separators; 3 – absorber; 4, 11, 17 – air coolers; 8 – heat exchanger; 9 – desorber; 10 - evaporator; 13, 18 – water coolers; 15, 19, 23 – pumps;

16 - water vapor condensate capacity; 20 – filter; 21 – absorbent capacity; 22 – capacity for concentration of absorbent solution; 24 – capacity for corrosion inhibitor; 25 – diaphragm pump

During various studies, it was found that TFO corrosion inhibitor forms a complex compound that shields the metal surface, i.e. covers the metal surface with a thin layer. No chemical reactions occurred on the metal surface. Adsorption of the synthesized TFO corrosion inhibitor on metals and the mechanism of action are presented in Figure 3.



**Figure 3. Adsorption of the synthesized inhibitor on metals and mechanism of action**

In the study, phosphorus, sulfur and nitrogen and hydrogen compounds for TFO corrosion inhibitor, even and odd electrons are very mobile, interact well with metal and have an inhibitory effect on metals, especially steel. The inhibitor created a very thin layer on the metal surface, protecting it from corrosion in the external environment[6,7].

**Conclusion.** In conclusion, the use of TFO corrosion inhibitor against corrosion in acidic and alkaline environments is considered the most effective for protecting metals, and the inhibitor slows down the chemical processes occurring on the metal surface under the influence of the external environment.

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## ASSESSMENT OF THE DEGRADATION PROCESS OF SOLAR PHOTOVOLTAIC PLANTS IN THE CLIMATIC CONDITIONS OF UZBEKISTAN

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**Abstract:** The article researches the degradation processes of PV panels at the 130 kW Namangan-Pop Solar photovoltaic plant (SPVP) as a result of seasonal climate effects. All PV panels installed in the SPVP are HSL 250, JSMM 2501, SM250 PC 8 and TS-S 400 polycrystalline solar panels manufactured by South Korean companies HANHWA, JSPV, S-ENERGY and TOPSUN. Among them, degradation processes were observed in HANHWA HSL 250 type solar panels. These degradation processes have been determined based on experimental researches based on the requirements of the International Standard. The comparison of the volt-ampere characteristics and power-voltage graphs of HANHWA's defective and new unused HSL 250 solar panels are presented. In Namangan-Pop Solar photovoltaic plant, reference ( $Y_r$ ) and final ( $Y_f$ ) production during the study period are averaged 4.12 hours and 3.67 hours per year, respectively and the production ratio (PR) varies between 87.24% - 93.58% and the average annual production ratio (PR) is 87.28% and the rate of degradation of SPVP between 2015-2021 was determined to be 0.224% per year on average.

**Keywords:** solar cell, solar panel, solar photovoltaic plant, degradation process, EVA film, reference ( $Y_r$ ) and final ( $Y_f$ ) production, production coefficient (PR).

**Introduction.** Currently, only 10.2% of all energy produced in the world is accounted for by renewable energy sources (RES). In particular, in the last five years, the share of renewable energy sources in providing global energy demand has exceeded 20 percent, and it is expected that by the end of 2023, the global production rate will be 12.4 percent [1,2,3]. Currently, renewable energy sources produce approximately 100 times less energy than conventional energy sources [3,5]. However, in the following years, the production of electricity with the help of solar photovoltaic power plants (SPVP) is increasing in the world. Overall growth in solar PV has increased by 50% between 2013-2019 and 2020-2022, which

means the construction of many solar photovoltaic power plants and the production of solar panels, which are the main part of them, increase their efficiency and performance resource and requires reducing degradation processes under the influence of external and internal factors that negatively affect the efficient operation of solar photovoltaic power plants [5].

The beginning of the construction of many solar photovoltaic power plants in Uzbekistan leads to an increase in the demand for analysis and research of solar panels, which are the main part of them. Because, as a result of their operation in real climatic conditions for a certain period of time, changes in their output parameters and degradation processes are observed

over time. In recent years, scientists around the world have been conducting a lot of research on the degradation of solar panels, studies [6,7] tried to determine the degradation process of solar panels during their operation in real conditions [8,9].

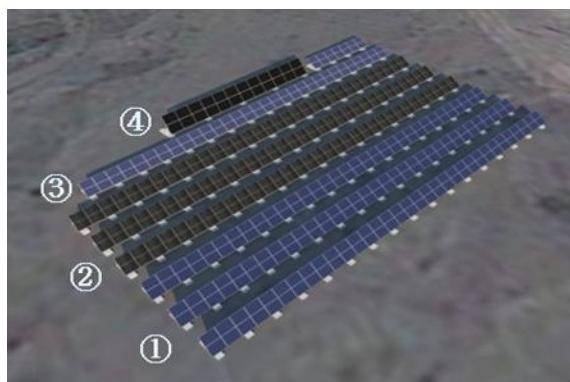
Thus, studying the process of degradation of solar panels and determining the causes of their occurrence and finding ways to prevent and eliminate them is one of the urgent issues of modern science.

This article presents research on the degradation process of polycrystalline silicon-based solar panels at the Namangan-Pop solar photovoltaic power plant in the climatic conditions of Uzbekistan after 7 years of operation.

**The object of the study.** The research object is a 130 kW solar photovoltaic power plant built for a test experiment in Pop district of Namangan region in 2015. All solar panels installed in

the solar photovoltaic power plant are HSL 250, JSMM 2501, SM250 PC 8 and TS-S 400 polycrystalline solar panels manufactured by South Korean companies HANHWA, JSPV, S-ENERGY and TOPSUN, and "KASO" and "DASS TECH" inverters manufactured in Germany [10,11]. The Namangan-Pop solar photovoltaic power plant is designed to produce an average of 500-600 kWh of electricity per day.

An overview of the location of the Namangan-Pop solar photovoltaic power plant and rows of installed solar panels, as well as the technical project of the location of the solar panels relative to the horizon are presented in Figures 1.a,b,). The solar panels in the 1st, 2nd and 3rd rows are fixed at an angle of 30° to the horizon, the solar panels of the 4th row are installed in such a way that they can be changed in the range of angles from 15° to 45° depending on the seasons.



a) Rows of solar panels



b) General view of Namangan-Pop solar photovoltaic power plant

**Figure 1. Technical project and general view of the arrangement of solar panels relative to the horizon**

The solar photovoltaic plant is connected in parallel to the power grid. Each company's solar panels are equipped with separate inverters and electricity meters.

**Research method and device.** During the years 2015-2021, a total of 830739 kWh of electricity was supplied to

the electric grid by the solar photovoltaic plant. In particular, the solar photovoltaic plant produced 141556 kWh of electricity in 2015, and 7 years later, and 138448 kWh of electricity in 2021. From these figures, it follows that the production efficiency of the solar photovoltaic power plant has decreased by 2.2% during these years. In

order to investigate the reason for this, when inspecting the outer surface of all the solar panels installed in the solar

photovoltaic plant, a number of defects appeared in the HSL 250 type solar panels of HANHWA (Figure 2).



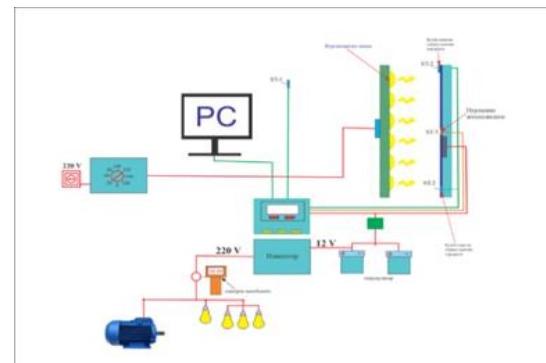
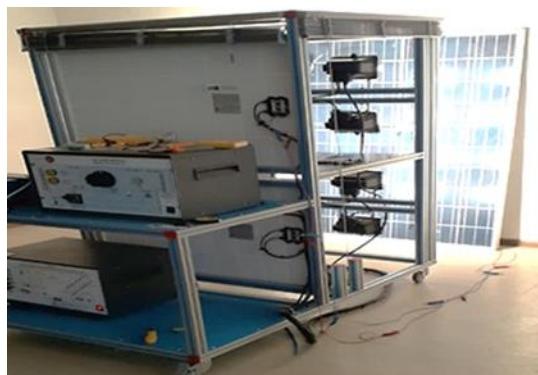
**Figure 2. HSL250 defective solar panels from HANHWA**

As the temperature of the solar panel exceeds the norm, air bubbles have appeared between the EVA film layer on the surface of the solar panels and the solar panel in some parts of the solar panel. As a result, some of the sunlight falling on the solar cell is scattered in these bubbles and does not reach the solar cell, resulting in a decrease in the efficiency of the solar panel.

In order to determine the efficiency of solar panels with such defects, one defective HANHWA solar panel was removed from a solar photovoltaic power plant. In order to compare the results obtained from measuring the output characteristics of this selected solar panel, a brand new solar panel from the same

HANHWA company in stock, which has not yet been used, was also selected. The output characteristics of this solar panel were brought to the laboratory for experimental measurement and research purposes. The laboratory is equipped with a special "EESFC" device that studies solar panels in the "SCADA" system of the "EDIBON" company.

This device allows for computer control of the study of the electric energy production of the solar panels and to carry out studies on all the characteristics and parameters of the solar panels [12]. The general view and connection diagram of the special "EESFC" device for studying solar panels in the "SCADA" system of the "EDIBON" company is presented in Fig. 3.



**Figure 3. Experimental research device overview and connection diagram**

Using this device, the intensity of the light falling on the solar panel  $J(W/m^2)$ , the

produced current  $I(A)$ , the voltage  $U(V)$  and the power  $P(W)$  were measured. In

addition, room temperature  $T_{rt}$  ( $^{\circ}\text{C}$ ) and solar panel temperature  $T_{pt}$  ( $^{\circ}\text{C}$ ) were measured each time the radiation intensity was increased. These measurements were taken separately for a new non-operational solar panel and separately for a solar panel operated for 7 years under real climate conditions.

**Measurement results.** Table 1 shows the results of the influence of the temperature of the solar panel on the output parameters for the case where the intensity of the light falling on the new non-operational solar panel is  $J=750\text{W/m}^2$ .

#### Parameter indicators of the non-exploited solar panel

Energy parameters	The temperature of the solar panel is $^{\circ}\text{C}$									
	31	35	39	43	47	51	55	57	59	61
U (V)	32,9	32,2	31,9	31,5	31,1	30,9	30,5	30,3	30,2	30,1
I (A)	6,71	6,84	6,85	6,87	6,88	6,89	6,95	6,98	7,00	7,01
P (W)	220,8	220,3	218,5	216,4	214,0	213,0	212,0	211,5	211,4	211,0

Table 2 shows the experimental results obtained on the effect of the defective solar panel temperature on the output parameters.

#### Parameter indicators of a solar panel operated for 7 years

Energy parameters	The temperature of the solar panel is $^{\circ}\text{C}$									
	31	35	39	43	47	51	55	57	59	61
U (V)	30,8	30,7	30,7	30,6	30,5	29,8	29,2	28,8	28,5	28,1
I (A)	6,58	6,58	6,59	6,59	6,61	6,62	6,63	6,64	6,65	6,66
P (W)	202,7	200,6	202,3	201,7	201,6	197,3	193,6	191,2	189,5	187,2

The volt-ampere characteristics (VAX) and power-voltage graphs of HANHWA HSL 250 defective and new unused solar panels are shown in Figures 4a) and b). The maximum voltage of the defective solar panel of HANHWA company HSL 250 type solar panel operated in real climate conditions for 7 years  $U_{max(def.SP)}=24.8\text{V}$ , the maximum voltage of the new unused solar panel  $U_{max(new.SP)}=25.9\text{ V}$  It was found to be equal to V. So, the generated voltage U(V) and current I(A) decreased by a certain value, i.e. 1.1%.

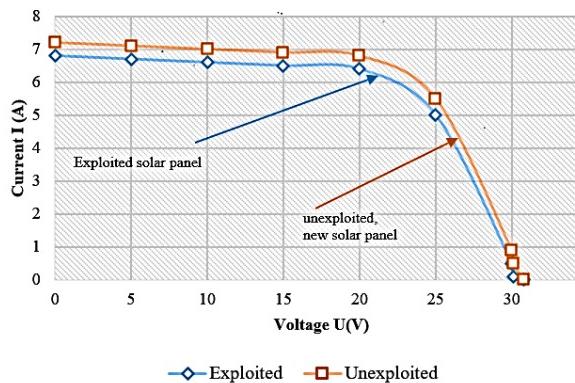
In order to determine the dependence of the power on the voltage, measurements were made when the temperature of the solar panels was  $T=40^{\circ}\text{C}$ . The obtained experimental results showed that the maximum power of a new, unused solar panel is  $P_{mp}=156\text{W}$ , and the maximum

power of a defective, i.e., operated solar panel is  $P_{mp}=146\text{W}$ .

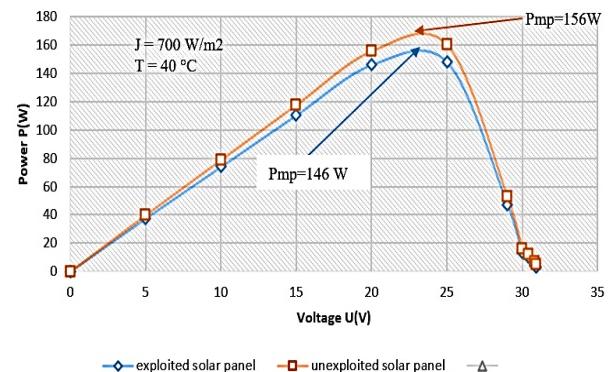
Similarly, short-circuit current  $I_{sc}(A)$  and direct voltage  $U_{oc}(V)$ , i.e., volt-ampere characteristics, were studied for values of  $550\text{ W/m}^2$ ,  $650\text{ W/m}^2$  and  $750\text{ W/m}^2$  irradiance intensity on the solar panel. As the radiation intensity  $J(\text{W/m}^2)$  falling on the solar panel increased, the direct voltage  $U_{oc}(V)$  decreased significantly, and the short-circuit current  $I_{sc}(A)$  increased slightly. When the radiation intensity was  $750\text{ W/m}^2$ , the no-load voltage  $U_{oc}=35.1\text{V}$  and the short-circuit current  $I_{sc}=7.2\text{A}$ . If the intensity of the light falling on the solar panel is  $J = 750\text{W/m}^2$ :  $P_{new(W)}$  is the effect of temperature on the output power of a new unused solar panel and an analysis of the effect of temperature on the output power  $P_{def.}(W)$  of a defective solar panel operated for 7 years showed that, indeed,

for both solar panels, the increase in solar panel temperature  $T(^{\circ}\text{C})$  decreases the output power  $P(\text{W})$ , it was found that the

output characteristics of the solar panels changed and the degradation processes started in the defective solar panels.



a) Volt-ampere characteristic of solar panel.



b) Power and voltage dependence of the solar panel

Figure 4.-a) and b) show the volt-ampere characteristics and power-voltage dependence of the HSL 250 type defective and new unused solar panel

**Research results.** International standard IEC-61724 requirements and authors' previous articles [13,14,15,16,17] were used to determine the speed of degradation processes in solar photovoltaic power plant. It is shown in Figure 5 that the average values of

reference ( $Y_r$ ) and final ( $Y_f$ ) production for the research period are 4.12 hours and 3.67 hours, respectively. Similarly, the variation of the efficiency coefficient of the Namangan-Pop solar photovoltaic power plant over the years is presented in Figure 6.

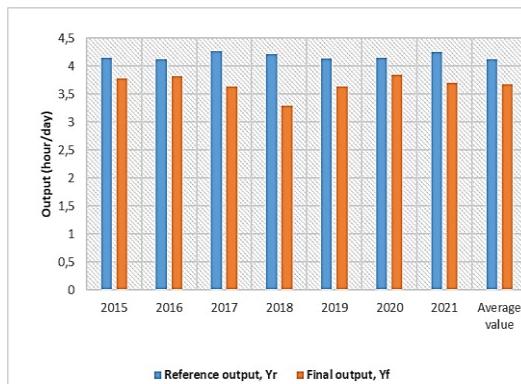


Figure 5. Hours of annual change in reference ( $Y_r$ ) and final ( $Y_f$ ) production over the study period

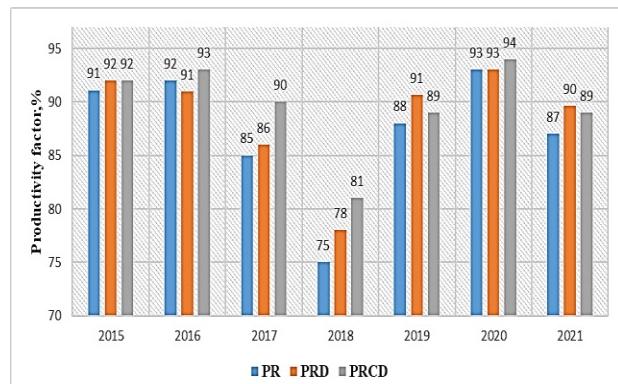


Figure 6. Annual changes in solar PV efficiency over the study period

The average annual efficiency ratios of the solar photovoltaic power plant were 80.74% - 87.25%. The difference-adjusted productivity rate was determined using the odds ratio ( $PR_D$ ), and the productivity rate for 2020 was 93%. The production ratios

(PR) and operating hours of the Namangan Pop solar photovoltaic power plant are compared with the operation of solar photovoltaic power plants in Europe and Asia in Table 3.

Table 3

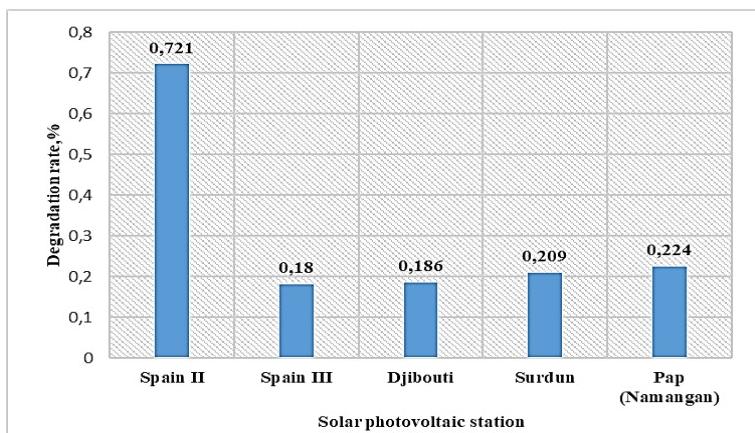
**Solar PV production coefficients in Europe and Asia**

Country	Research period (years) / maximum capacity	Technology	PR (%)	Range of values for PR (%).	Reference ( $Y_r$ ) production (day/hour)	Final ( $Y_f$ ) production (day/hour)	Application
Sardinia, Italy	1 year 300 kW	p-Si	83.20	74.81 to 89.93	----	----	(Ghiani et al., 2013)) (Martín-Martínez et al., 2019)
Spain II	3 years 4.6 MW	p-Si	85.09	83.56 to 87.12	7.25	6.16	(Martín-Martínez et al., 2019)
Spain III	3 years 370 kW	p-Si	80.96	80.39 to 81.43	5.46	4.42	(Martín-Martínez et al., 2019)
Surdun, France	7 years 4.5 MW	p-Si	87.18	84.12 to 90.54	3.92	3.33	Mohamed El Hacen et al., 2018)
Pop-Namangan Uzbekistan	7 years 130 kW	p-Si	87.02	75.85 to 93.28	4.12	3.67	Results of research

From Table 3, it is known that in Italy (Sardinia) the annual production coefficient (PR) of solar photovoltaic power plants was 83.20%, and in Spain II and Spain III the production coefficients (PR) of solar photovoltaic power plants were 85.08% and 80%. It was determined to be 96%. In this, in Spain II reference ( $Y_r$ ) and final ( $Y_f$ ) production hours changed from 7.25 to 6.12, a difference of 1.09 hours. In Spain III, reference ( $Y_r$ ) and final ( $Y_f$ ) production hours changed from 5.46 to 4.42, a difference of 1.04 hours. Hence, the reference ( $Y_r$ ) and final ( $Y_f$ ) production hours in Spain II and Spain III differed by about 1.06 hours. Similarly, the production coefficient (PR) in France (Surdun) was found to be 87.18%. In this case, the reference ( $Y_r$ ) and final ( $Y_f$ ) production hours differed by 0.89 hours. Therefore, the production energy efficiency of solar photovoltaic power plants in France is higher than in Spain. According to the

results of scientific studies of the Namangan-Pop solar photovoltaic power plant for 7 years, the production coefficient (PR) was found to be 87.02%. In this case, reference ( $Y_r$ ) and final ( $Y_f$ ) production hours changed from 4.12 to 3.67, a difference of 0.45 hours.

So, it was determined that the production energy efficiency of solar photovoltaic power plants in the climatic conditions of Uzbekistan is higher than that of Spain and France. A comparison diagram of the degradation level of Namangan-Pop solar photovoltaic power plant with solar photovoltaic power plants in other European and Asian countries is presented in Figure 7. Degradation rates, determined from the slope of the efficiency decline, ranged from 0.18% to 0.209% per year for Spain III and 0.721% for Spain II during 3 years or more of operation of solar PV plants in Spain.



**Figure 7. Comparison diagram of solar photovoltaic power plants in Asia and Europe with the degradation rate of Namangan-Pop Solar PV (Uzbekistan)**

In Djibouti, despite having a tropical desert-marine climate, the degradation rate was 0.186% per year. In another study in a temperate climate, the degradation rate of Solar PV in France (Surdun) was 0.209% per year.

Thus, it was found that the degradation rate of Namangan-Pop Solar PV in the period 2015-2021 is 0.224% per year on average.

**Conclusions.** Based on the results of a study of the degradation process of solar panels based on polycrystalline silicon in the climatic conditions of Uzbekistan after 7 years of operation, the following were obtained:

- As a result of the increase in the temperature of the solar panels during the hot days in the climatic conditions of Uzbekistan, defects appeared on the surface of the solar panels of the HANHWA company, and it was found that this is a degradation process.

- It was determined that the maximum electric energy produced in Namangan-Pop QFES in 2020 was 143871kWh, and the minimum electric energy was 127468kWh in 2018, and its production efficiency decreased by 2.2% during 2015-2021.

- In experimental studies, due to changing the intensity of light falling on the solar panel, it was determined that its output power, voltage and current change depending on the temperature.

- In Namangan-Pop QFES, the reference ( $Y_r$ ) and final ( $Y_f$ ) production during the study period averaged 4.12 hours and 3.67 hours per year, respectively, and the production ratio (PR) varied between 87.24% - 93.58% and average annual production rate (PR) was found to be 87.28%.

- It was determined that the degradation rate of Namangan-Pop solar photovoltaic power plant between 2015 and 2021 is 0.224% per year on average.

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# PHYSICAL-MECHANICAL PROPERTIES OF COMPOSITE MATERIALS BASED ON VERMICULITE, BAZALT, WOLLOSTANITE, AND POLYETHYLENE P-Y 342 AND POLYAMIDE PA-6

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**Abstract:** The article describes how to fill polypropylene with oligomers containing nitrogen, phosphorus, and metal to produce heat-resistant and mechanically strong thermoplastic composite materials. Polypropylene compositions, solution flow index determination, viscometric methods, bending strength determination using two-support methods, and bending, Charpy impact strength measurement methods are all discussed. The amount of filler used in the production of composite materials based on basalt mineral from polyvinyl chloride ranged from 1 mass part to 5 mass parts. The physicomechanical characteristics of the developed composite materials revealed that increasing the amount of filler decreases the material's fluidity. The optimal amount of basalt-containing fillers in the composite material, according to the results, is 5 parts by mass.

**Keywords:** polyvinyl chloride, basalt mineral, atomic force microscopy, physical-chemical and mechanical properties.

**Introduction.** Obtaining nanofillers and composite materials based on them, as well as applying them in numerous domains of industry and technology, is currently of great interest to researchers [1]. Nanoadditives are applied to polymers in huge quantities, just like regular fillers [2]. Because polyethylene P-Y 342 has a high degree of crystallinity, it has higher elongation than other forms of polyethylene. It is also resistant to moisture, corrosion, and abrasion, as well as most chemicals [3]. P-Y 342 comprises dispersion vermiculite and basalt, as well as basalt fibres in high quantities, ranging from 20 to 40 mas. The effect of adding up

to% on polyethylene characteristics was investigated [4]. The properties of these fillers are shown in P-Y 342 30 mas.% was compared with the properties of boron inserted in the quantity, as provided in the literature analysis, this amount is commonly used for kinds of polyethylene suitable for pipe manufacture [5]. Furthermore, it was discovered that the P-Y 342/PEMA/TEAS/VK composition had effective qualities when compared to other types of vermiculite-based compositions [6]. The results demonstrate that the tear resistance and impact resistance of composites based on P-Y 342 are low at

high modifier concentrations. The ideal modifier concentration is 1.0 mas. is% [7].

**The results are correct.** However, the tensile strength varies from 21 MPa in the original polyethylene to 38 MPa to 48 MPa for P-Y 342/TEAS/VT and P-Y 342/PEMA/TEAS/VT additive composites.

Table 1 displays the established comparative properties of modified polymer composite materials based on PA-

6 and fillers. As shown in the table, the basic composition in PA-6/PEMA/TEAS/B with its impact resistance and tear strength qualities outperforms PA-6/PEMA/TEAS/VK added exhibits.

Table 1 shows that the modifier is 1.0 mas in the area of TEAS. %, the impact resistance of the compositions reaches the highest level (from 100 to 118 kJ/m<sup>2</sup>).

Table 1

**Physical and mechanical properties of composite materials based on mineral fillers: vermiculite (VK), basalt (BT), wollastonite (VT), and polyamide PA-6 were compared**

Compositions	Impact resistance, kDj/m <sup>2</sup>	$\sigma$ bending strength, MPa	$\sigma$ tensile strength, MPa	Relative elongation, %	Relative narrowness, %
	GOST 4647-80	GOST 4648-80	GOST 1423681	GOST 1423681	GOST 1859921
PA-6	100	90	66	150	2
PA-6/VK	109	94	66	65	1,7
PA-6/TEAS/VK	112	98	68	55	1,8
PA-6/PEMA/TEAS/VK	116	100	73	55	1,5
PA-6/BT	110	95	67	66	1,7
PA-6/TEAS/BT	115	98	69	58	1,8
PA-6/PEMA/TEAS/BT	118	102	75	57	1,8
PA-6/VT	108	94	66	70	1,8
PA-6/TEAS/VT	110	96	68	64	1,7
PA-6/PEMA/TEAS/VT	112	100	73	62	1,6
PA-6/Bur	106	92	66	60	2,4

The modifier TEAS is included in the compositions at a concentration of 1.0% by mass in respect to the mass of the filler.

Fillers were added to 1.0 mas of modifier TEAS to PA-6. When it is applied in % amount, its impact resistance is boosted when compared to compositions without modifier.

When maleated polyethylene and TEAS are combined to a PA-6-based composition, the impact resistance increases dramatically. 1.0 mas.% TEAS and 30 mas.% vermiculite and basalt

compositions significantly increase impact resistance.

As a result, the impact resistance has a maximum value and ranges from 100 for the original PA-6 to 112 and 116 kJ/m<sup>2</sup> for the PA-6/TEAS/VK and PA-6/PEMA/TEAS/VK compositions, respectively, as well as PA-6/PEMA/TEAS/VK compositions. It rises to 115 and 118 kJ/m<sup>2</sup> for TEAS/BT and PA-6/PEMA/TEAS/BT composites, respectively.

The addition of fillers containing the modifier TEAS to PA-6 raises the impact resistance of composite materials from 100 to 115 kJ/m<sup>2</sup>, while the addition of the compatibilizer PEMA raises the impact resistance from -100 to 118 kJ/m<sup>2</sup>.

Modifiers are crucial in modifying the properties of composites based on them. This is possible due to their interfacial contact with the polymer basis.

The addition of modifiers to the composition of composites has the effect of enhancing tear resistance.

The results reveal that the modifiers have an effect on improving the physical and mechanical properties of the nanoparticle-filled composite materials.

Because of their enormous relative surface area, nanoparticles adhere well to the polymer base, and some agglomerations are seen. Tear resistance is greatest in the PA-6/PEMA/TEAS/BT combination.

According to the results, a relatively high value of tear resistance (75 MPa) is observed in the composition based on PA-

6, the amount of modifier TEAS is 1.0 mas.%, and it is observed when the filling level of basalt reaches 30 wt.%.

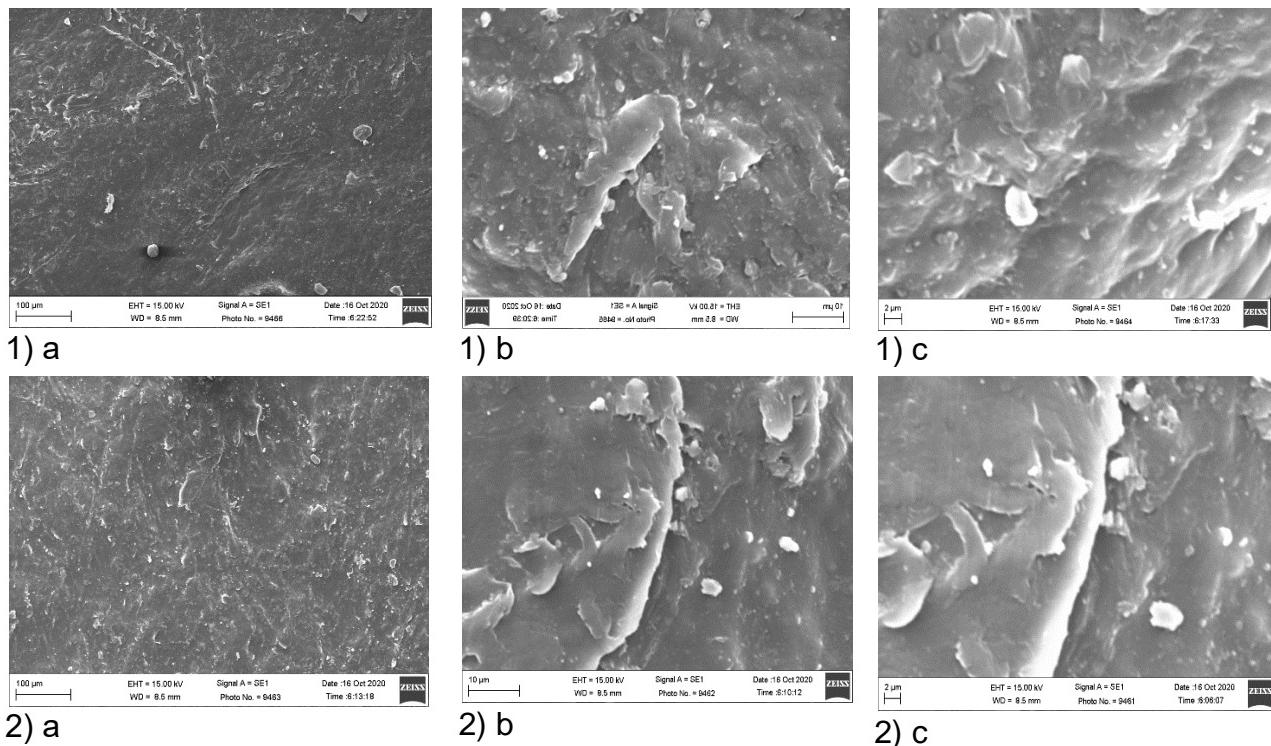
Flexural strength increases as a function of modifier concentration in composites filled with fillers, although less than impact and tensile strength.

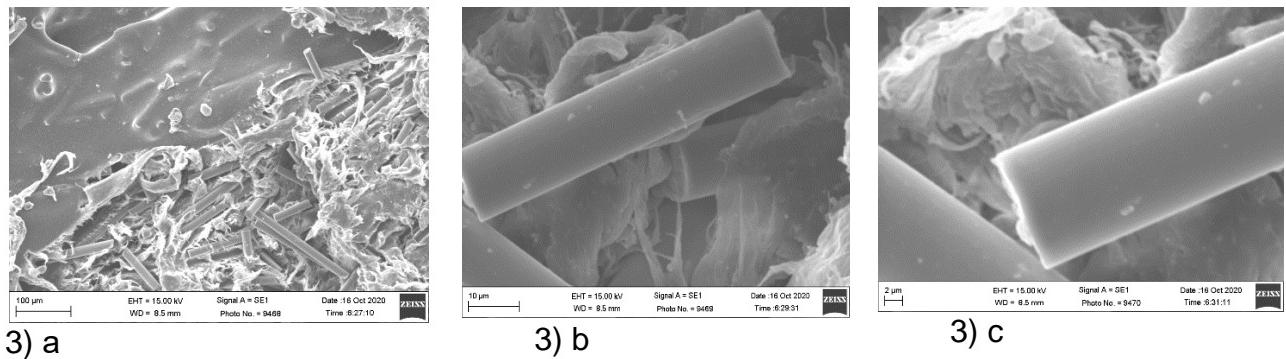
As a result, the concentration of the modifier is 1.0 mas.% amount is adequate for the optimal characteristics of the physical-mechanical properties of the composition based on PA-6.

The addition of modifiers to the formulation of composite materials increased the mechanical properties of PA-6 and, as a result, improved nanoparticle dispersion.

It is worth noting that the bending strength is 30 mas. % is significantly higher in composite materials with modified fillers than in composite materials with unmodified fillers. As a result, 1.0 mas. Flexural strength is greatest in maleinated PA-6 composite materials with% TEAS.

Figure 1 depicts SEM pictures of composite materials.





**Figure 1: SEM pictures of mineral-based composite materials: vermiculite (VK), basalt (BT), wollastonite (VT), and polyamide. PA-6 at various scales (a-100m, b- 10m, v-2m) 1) PA-6, PEMA, TEAS, and VK 2)PA-6/PEMA/TEAS/BT 3) PA-6, PEMA, TEAS, and BV**

Figure 1 shows that the fillers are equally dispersed in the polymer matrix with the same size in all of the composites. The photographs were obtained at a size of 2 m to 100 m, showing that the composites are nanoscale.

**Conclusion.** As a consequence of the research on the rheological properties of composite materials based on polymers and fillers, 30% mass was added to the composition. The amount of filler injected

drastically reduced the value of SOC when compared to the initial polymers. The composition comprises 1.0 mas. The addition of modifier TEAS in the amount of % caused a decrease in fluidity and an increase in viscosity in the studied temperature range, and the study of the rheological properties of composite materials based on PA-6 and P-Y 342 can be the basis for establishing optimal processing conditions.

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## BENTONITE AND PHOSPHORITE PRODUCTION OF ORGANOMINERAL FERTILIZERS BASED ON RAW MATERIALS AND NITROGEN-FIXING MICROORGANISMS ((CD:B:NFM=100:5:(0-4)), (CD:B:PF:NFM=100:5:5:(0-4)))

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### Abstract:

**Objective.** This article deals with production of organomineral fertilizers based on local raw materials cattle dung (cattle). local ores (Kyzilkum phosphorite flour (PF) and Navbahor bentonite) and nitrogen-fixing microorganisms. Based on the experiments. the following results were obtained. During 60 days. the raw materials selected for the experiment were used in optimal proportions: cattle dung: bentonite: nitrogen-fixing microorganisms solution (NFM) (100:5:0-4) and the main chemistry of organomineral fertilizers obtained on the basis of cattle dung. bentonite. phosphorite flour and nitrogen-fixing microorganisms. Composition (CD:B:PF:NFM=100:5:5:(0-4)) was analyzed.

**Methods.** The obtained results from our side were first studied the quantities of organomineral fertilizers based on cattle dung. bentonite and nitrogen-fixing microorganisms. Cattle dung. bentonite and nitrogen-fixing microorganisms of the type Azotobacterium were used for laboratory research. For this. cattle dung: bentonite ratios were taken in the range of 100:(2.5-5) and the resulting mixture was processed with nitrogen-fixing microorganisms (NFM) grown in Fedorov medium in the ratio of 100:(2.5-5):(0.5-4.0).

**Results** Physico-chemical and commercial properties of the obtained new type of organomineral fertilizers. It is known that physico-chemical (dispersibility. natural slope angle. etc.) and commodity properties (hygroscopic point. grain strength. etc.) are important properties of solid and powder fertilizers used in agriculture. Because these properties. especially commodity properties. determine the conditions of storage of fertilizers in warehouses. transportation in vehicles and direct application.

**Conclusions** Laboratory experiments on the production of organomineral fertilizers based on nitrogen-fixing microorganisms. cattle dung and bentonite were carried out and their optimal ratios were determined: depending on the change of the CD:B:NFM ratio. it is in the range of 0.336-0.35%. and in the

case after 60 days it is 1.138-1.513%. It can be seen that the amount of nitrogen in the obtained fertilizer samples increases 3.4-4.6 times.

**Keywords.** Kyzylkum phosphorite flour (PF), Navbahor bentonite, cattle dung, biofixation, humic substances, fulvic acids, composting, physicochemical, commodity, nitrogen.

**Introduction.** Due to the rapid increase in the number of people in the world. providing them with sufficient food products is one of the important problems. Adequate use of organomineral fertilizers (OMF) through nitrogen-fixing microorganisms is necessary to solve this problem. By creating an optimal nutrient environment for nitrogen-fixing microorganisms. it is important to research in the direction of achieving the process of maximum nitrogen fixation in the air and creating a flexible technology for the production of OMFs enriched with various components.

The analysis of the studied literature and scientific articles shows that the employees of the Institute of General and Inorganic Chemistry of the Academy of Sciences of the Republic of Uzbekistan have studied various processes of obtaining OMF based on the lignite of the Angren mine. OMF with the following composition (wt.%) was obtained by oxidation of Angren lignite with nitric acid and subsequent decomposition of Central Kyzylkum phosphorites with nitric acid-coal slurry: total P<sub>2</sub>O<sub>5</sub>. - 9.41; P<sub>2</sub>O<sub>5</sub> absorbed by citric acid. - 7.71; absorbed P<sub>2</sub>O<sub>5</sub> on trilon B.- 4.78; CaO water. - 11.27; N - 7.75; OS - 23.62 [1].

Processes for obtaining liquid and solid nitrogen-humic fertilizers by stepwise oxidation of lignite are presented in [2].

In [3. 4]. the oxidation of lignite with nitric acid in the presence of phosphogypsum. followed by neutralization of the oxidized products with ammonia. contained 14.19% nitrogen. 20.70% HA. 32.26% OS. 5.38% water-soluble SO<sub>3</sub> and OMFs containing 2.31% water-soluble CaO were obtained. Currently. the level of use of phosphorus fertilizers is on average 15-25%.

O'.Sh.Temirov. A.M. Reymov and Sh.S.Namazov carried out scientific and

research work on obtaining organomineral fertilizers based on phosphate waste. nitric acid. cattle dung and poultry waste [5-17].

In these works. several options for obtaining OMFs were developed: cattle dung and phosphorites; poultry waste and phosphorus; cattle dung. phosphorites. various mineral fertilizers. phosphogypsum and bentonite; on the basis of poultry waste. phosphorites. various mineral fertilizers. phosphogypsum and bentonite. Experiments were conducted on the preparation of phosphorous fertilizers based on mineralized mass and cattle dung. In addition. options for obtaining OMF by composting phosphorites (MM and FSh) with a mixture of recycled poultry waste with nitric acid and activating phosphorites with nitric acid and then processing with poultry waste were studied. The economic efficiency of obtaining OSs was calculated and agrochemical tests were carried out on cotton plants on ordinary gray soils. However. this research work has not been applied to industry. It is clear from the above information that the creation of rational technologies for the production of organic fertilizers based on low-grade phosphorites with high agro-ecological value and efficiency and on the basis of nitrogen-fixing microorganisms is a major task.

The main raw materials used in laboratory work for scientific research were cattle and poultry dung. phosphorite flour (PF) from Central Kyzyl-Kum phosphate raw materials. and various bentonite samples. The main chemical composition of these raw materials is presented in Table 1 [18, 19].

Microorganisms of the type Azotobacterium were used to fix molecular nitrogen from the air. In addition. urea. ammonium sulfate and potassium chloride

from mineral fertilizers produced at chemical plants of our country were used to obtain organomineral fertilizers with different nutrient components.

**Table 1  
The main chemical composition of cattle dung, phosphorite flour and bentonite**

Raw material	Humi dity	Organic substa nces	Humic acids	Fulvic acids	Water-soluble organic substa nces	NonW ater-soluble organic substa nces	P <sub>2</sub> O <sub>5</sub>	N	K <sub>2</sub> O	CaO	Extra subst ance
Cattle dung	55.4	26.53	7.1	3..7	2.52	13.24	0.28	0.5 1	0.58	0.59	16.1 1
PF	P <sub>2</sub> O <sub>5</sub>	CaO	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	MgO	F	CO <sub>2</sub>	SO <sub>3</sub>	Э.к..	P <sub>2</sub> O <sub>5</sub> уmy	CaO/ P <sub>2</sub> O <sub>5</sub>
	17.75	47.52	0.95	0.73	1.78	2.0	17.03	3.2 7	5.27	17.74	2.67
Navbahor bentonite	SiO <sub>2</sub>	TiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	MgO	CaO	N	K <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>	CO <sub>2</sub>	E.S
	57.9	0.35	13.69	5.10	1.84	0.48	1.53	1.7 5	0.43	0.75	16.1 7

**Methods.** The obtained results from our side were first studied the quantities of organomineral fertilizers based on cattle dung, bentonite and nitrogen-fixing microorganisms. Cattle dung, bentonite and nitrogen-fixing microorganisms of the type Azotobacterium were used for laboratory research. For this, cattle dung: bentonite ratios were taken in the range of 100:(2.5-5) and the resulting mixture was processed with nitrogen-fixing microorganisms (NFM) grown in Fedorov medium in the ratio of 100:(2.5-5):(0.5-4.0).

The obtained results are presented in Table 2. An increase in humic and fulvic

acids, water-soluble organic matter (WSOM) is observed in the fertilizer samples obtained as a result of processing a mixture of cattle dung and bentonite with nitrogen-fixing substances. For example, in the mixture of organomineral fertilizers on the day of preparation, the amount of HA, FA and WSOM is 2.48%, 2.60% and 2.46%, respectively, and when NFM is processed with microorganisms, it is 2.43%, 2.54% and 2.41%, but after 60 days these numbers are as below 4.10%, 4.10-4.29% and 4.06%.

**Table 2  
Chemical composition of organomineral fertilizer samples based on cattle dung, bentonite and nitrogen-fixing microorganisms (CD:B:NFM=100:5:(0-4))**

Ratio	P <sub>2</sub> O <sub>5</sub> total.%	CaO <sub>total.</sub> %	OM.%	HA.%	FA.%	WSOM.%	K <sub>2</sub> O.%	N <sub>total.</sub> %	Humidity.%
After a day									
100 : 5 : 0	0.236	0.630	19.93	2.48	2.60	2.46	0.572	0.336	63.48
100 : 5 : 0.5	0.235	0.627	19.85	2.48	2.59	2.45	0.570	0.335	63.63
100 : 5 : 1	0.234	0.624	19.77	2.47	2.58	2.44	0.567	0.333	63.78
100 : 5 : 2	0.232	0.619	19.61	2.45	2.56	2.43	0.563	0.331	64.07
100 : 5 : 4	0.230	0.614	19.46	2.43		2.41	0.558	0.328	64.36

After 60 days										
100 : 5: 0	0.298	0.796	21.08	3.58	3.75	3.55	0.723	0.350	53.83	
100: 5 : 0.5	0.301	0.804	21.42	3.75	3.92	3.71	0.731	1.138	53.35	
100 : 5 : 1	0.304	0.813	21.82	3.92	4.10	3.88	0.739	1.280	52.86	
100 : 5 : 2	0.306	0.817	22.07	4.01	4.19	3.97	0.743	1.374	52.61	
100 : 5 : 4	0.308	0.821	22.38	4.10	4.29	4.06	0.747	1.513	52.35	

It was also found to increase nitrogen content in dung samples recycled with NFM. The nitrogen content of the fertilizer sample taken without treatment with NFM on the day of preparation is 0.336%. and after 60 days it is 0.35% in the same condition. that is. the total nitrogen content in this case is slightly reduced. but with treatment with NFM depending on the change of CD:B:NFM ratios on the day of preparation. it is in the range of 0.335-0.328%. and after 60 days it is 1.138-1.513%. It can be seen that the amount of nitrogen in the obtained fertilizer samples increases 3.4-4.6 times.

It can be seen from the results of Table 3. when the mixture made of

phosphorite flour. cattle dung and bentonite is processed with nitrogen-fixing microorganisms (NFM). NFM has an effect on increasing the content of HA. FA and WSOM and nitrogen in the obtained organomineral fertilizers. For example. 0.917% total P<sub>2</sub>O<sub>5</sub> in compost 1 day after preparation when the CD:B:PF:NFM ratio is 100:5:5:4. and the amount of its relative absorbable form is equal to 23.15%. these values in the obtained compost (ready organomineral fertilizer) after 60 days are equal to 1.246 and 73.17%. respectively. In this case. not only the amount of total P<sub>2</sub>O<sub>5</sub> increases. but also an increase in its relative absorbable form is observed.

Table 3  
**The main chemical composition of organomineral fertilizers obtained on the basis of cattle dung. bentonite. phosphorite flour and nitrogen-fixing microorganisms (CD:B:PF:NFM=100:5:5:(0-4))**

Ratio	P <sub>2</sub> O <sub>5</sub> total. %	Relative value of P <sub>2</sub> O <sub>5</sub> <sub>usv</sub> according to Tr.B. (%)	CaO <sub>total</sub> . %	Org subs. %	HA. %	FA. %	WSOS. %	K <sub>2</sub> O %	N <sub>total</sub> . %	Humidity. %
After a day										
100:5:5:0	0.940	21.62	2.52	19.93	2.63	2.76	2.61	0.572	0.418	63.48
100:5:5:0.5	0.936	21.89	2.50	19.85	2.62	2.74	2.60	0.570	0.416	63.63
100:5:5:1	0.932	22.43	2.49	19.77	2.61	2.73	2.59	0.567	0.415	63.78
100:5:5:2	0.925	22.73	2.47	19.61	2.59	2.71	2.57	0.563	0.411	64.07
100:5:5:4	0.917	23.15	2.45	19.46	2.57	2.69	2.55	0.558	0.408	64.36
After 60 days										
100:5:5:0	1.188	59.82	3.18	21.08	4.13	4.31	4.09	0.723	0.435	53.83
100:5:5:0.5	1.201	68.31	3.21	21.42	4.31	4.51	4.27	0.731	1.415	53.35
100:5:5:1	1.213	69.39	3.25	21.82	4.50	4.71	4.46	0.739	1.592	52.86
100:5:5:2	1.220	71.10	3.26	22.07	4.60	4.81	4.56	0.743	1.709	52.61
100:5:5:4	1.246	73.17	3.34	22.75	4.78	5.00	4.74	0.759	1.913	51.58

[21]. In the compost prepared in the same proportions. the amounts of HA. FA. WSOM. K<sub>2</sub>O and nitrogen will be equal to 2.57. 2.69; 2.55; 0.558 and 0.408%

respectively. After 60 days. in the composition of organo-mineral fertilizers taken in the same ratio. the amounts of HA. FA. WSOM. K<sub>2</sub>O and nitrogen will be equal to 4.78.; 5.00; 4.74; 0.759 and 1.913% respectively. General legalities of this type are also observed in other relations of CD: B:PF:NFM.

In addition. the following can be seen from the results of this table: with an increase in the amount of NFM. the amount of the relative absorbable form of phosphorus increases. and the amount of nitrogen in the obtained organomineral fertilizers also increases. For example. if the ratio of CD: B:PF: NFM is 100:5:5:0.5 and the value of the relative absorbable form of phosphorus in the compost obtained after 60 days is 68.31% and the amount of nitrogen is 1.415%. bu when the ratio of CD: B:PF: NFM is 100:5:5:4.0. it is equal to 73.17and 1.913% respectively.

**Results.** Physico-chemical and commercial properties of the obtained new

type of organomineral fertilizers. It is known that physico-chemical (dispersibility. natural slope angle. etc.) and commodity properties (hygroscopic point. grain strength. etc.) are important properties of solid and powder fertilizers used in agriculture. Because these properties. especially commodity properties. determine the conditions of storage of fertilizers in warehouses. transportation in vehicles and direct application.

To study the hygroscopic points of this type of fertilizers. the samples of organomineral fertilizers listed in Table 4 below were used.

The initial moisture content of organomineral fertilizer samples taken to determine hygroscopic points was as follows: %: 1 - 3.11%; 2 - 3.32. The hygroscopic points of these samples were as follows: sample 1 - 76%. sample 2 - 74%.

Table 4  
The main chemical composition of organomineral fertilizers

Samples of fertilizers	Sample humidity. %	P <sub>2</sub> O <sub>5</sub> total.	Relative value of P <sub>2</sub> O <sub>5</sub> usv according to Tr.B. (%)	Chemical composition %				
				CaO <sub>total.</sub> %	CaO <sub>total.</sub> %.	K <sub>2</sub> O. %	N	Hygroscopic point. %
CD: B: NFM.	3.11	0.308	-	22.38	0.821	0.747	1.513	76
CD: B:PF:NFM.	3.32	1.246	73.17	22.75	3.34	0.759	1.913	74

As can be seen from these values. the obtained organomineral fertilizer samples correspond to the average atmospheric humidity. but during storage in the autumn-winter and winter-spring periods. when the relative humidity is very high. they absorb water. that is. they become wet. Therefore. it is recommended to store and transport them in polypropylene bags.

In the subsequent experiments. some physico-chemical properties (dispersibility. natural slope angle. etc.) of powdered organomineral fertilizer samples we

determined. The dispersibility of organomineral fertilizers was determined using a Mering funnel. The experiments were carried out as follows: first. the outlet of this flask was checked for cleanliness and its suitability. that is. it was not damaged and not bent. then the flask was installed on three legs and its bottom hole was closed with a metal plate or cardboard paper while holding it by hand. and a sample of 100 g of organomineral fertilizer powder was drawn into the funnel.

After that, the covering metal plastic or cardboard paper was removed and at the same time the stopwatch was started. The stopwatch was stopped when the last

powder fell from the funnel hole. The dispersion of fertilizer samples was calculated in points [22, 23].

Table 5.  
Some physicochemical indicators of new types of organomineral fertilizers

Fertilizer samples	H <sub>2</sub> O. %	Pile weigh . g/cm <sup>3</sup>	Volumetr c gravity.e/ cm <sup>3</sup>	Durabilit y. mPA/cm <sup>2</sup>	Dispers ion. point	Natural slope. °	Fluidity. c
CD: B: NFM.	3.11	0.621	0.84	1.73	7.8	40.7	42
CD: B:PF: NFM.	3.32	0.611	0.94	1.85	8.05	41.8	45

The obtained results are presented in Table 5. The results showed that the dispersibility of the fertilizer samples was 7.8. 8.05 points respectively. This shows that the values have a good dispersion in the ten-point system. In addition, the natural slope angle of the free surface of the samples plays an important role in evaluating the mobility of fertilizer particles.

The smaller the natural angle of inclination, the more mobile the powder-like

substance is. The natural imaginary angles of the above organomineral fertilizer samples are 40.7° 41.8°. This shows that the mobility of these samples is close to each other. The bulk weight of organomineral fertilizers, which describes the size of their movement in storage warehouses and modes of spillage from bunkers and supply equipment.

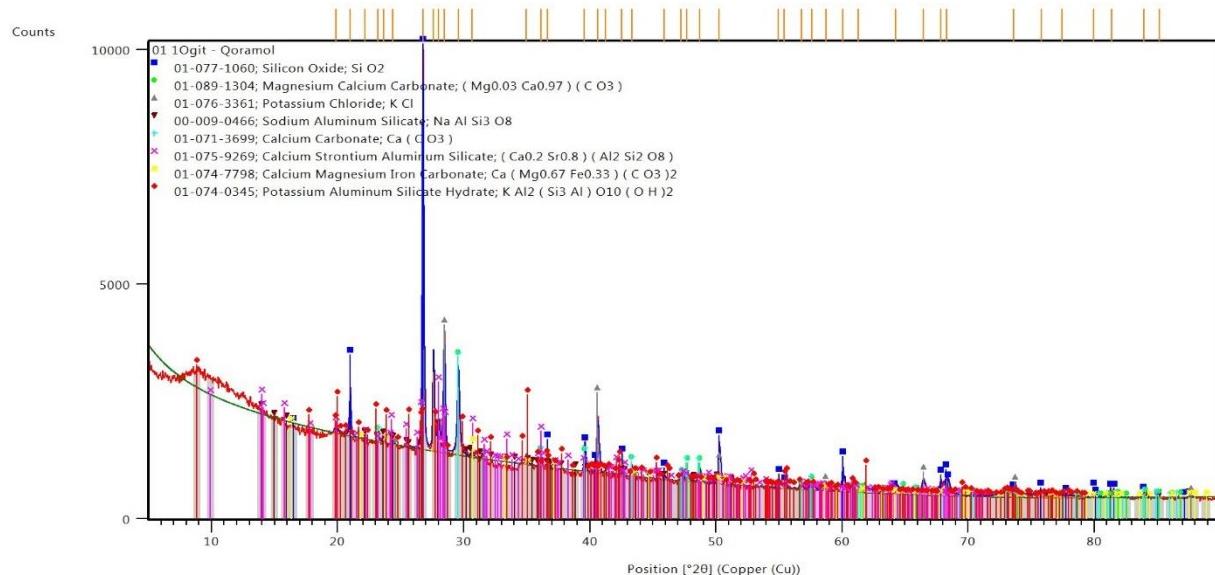


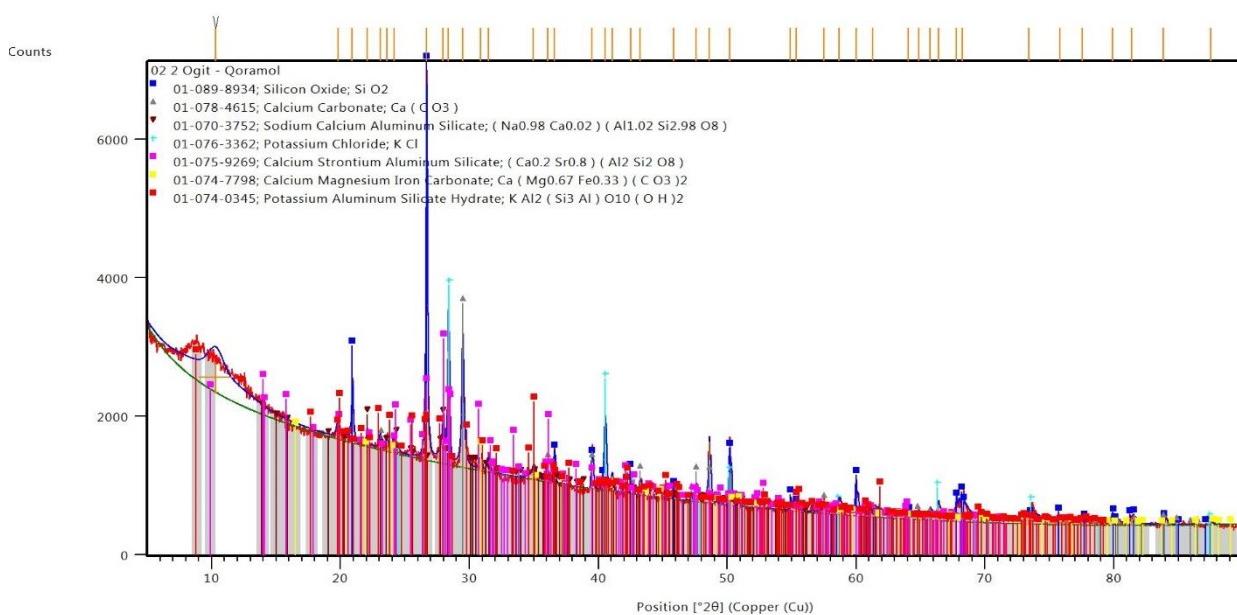
Fig. 1. X-ray analysis of a sample of organomineral fertilizer with a ratio of CD:B:NFM.=100:5:4.

The purpose of determining the weight of the pile is to calculate the dimensions of the bunkers, the efficiency of the transport and supply equipment, and to

determine the pressure exerted on the walls and the mechanism of opening and closing of the container of spraying substances.

The bulk weight of these 2 organomineral fertilizer samples is 0.621. 0.611 g/cm<sup>3</sup>. respectively. which fully meets the general requirements set by production plants [24]. In our subsequent works. the mineral composition of the above-obtained organomineral fertilizers was studied through elemental and X-ray phase studies [25]. As can be seen from these results. the organomineral fertilizer obtained in the ratio CD: B: NFM.=100:5:4

contains 55% SiO<sub>2</sub>. 4% dolomite. 3% potassium chloride. 2% sodium aluminum silicate. 20% potassium aluminum hydrosilicate. 10% calcium strontium silicate. 6 There are % calcium carbonate and calcium magnesium iron carbonates. Figure 2. this organomineral an x-ray analysis of the fertilizer is given. in which the mineral composition of the fertilizer is given.



**Fig. 2. X-ray analysis of a sample of organomineral fertilizer with CD:B:PF:NFM =100:5:5:4**

As can be seen from these results. the organomineral fertilizer obtained in the ratio CD:B:PF:NFM=100:5:5:4 contains 26% SiO<sub>2</sub>. 5% potassium chloride. 12% sodium calcium aluminum silicate. 26% potassium aluminum hydrosilicate. 21% contains calcium strontium aluminum silicate. 8% calcium carbonate and 1% calcium magnesium iron carbonates.

**Conclusions.** Laboratory experiments on the production of organomineral fertilizers based on nitrogen-fixing microorganisms. cattle dung and bentonite were carried out and their optimal ratios were determined: depending on the change of the CD:B:NFM ratio. it is in the range of 0.336-0.35%. and in the

case after 60 days it is 1.138-1.513%. It can be seen that the amount of nitrogen in the obtained fertilizer samples increases 3.4-4.6 times.

The processes of obtaining organomineral fertilizers based on nitrogen-fixing microorganisms. cattle dung. bentonite and phosphorite flour were studied. The optimal quantities of this type of organomineral fertilizers were determined: when the ratio of CD:B:PF:NFM was 100:5:5:0.5 and after 60 days. the value of the relative absorbable form of phosphorus in the compost was 68.31%. and the amount of nitrogen was 1.415%. is equal. the ratio of CD:B:PF:NFM is 100:5:5:4.0. and it is

73.17 and 1.913%. According to the results of the conducted research. some physico-chemical and commodity properties of 2 new types of organomineral fertilizer samples were studied. The dispersion of organomineral fertilizer samples is equal to 7.8 and 8.05 points. respectively. and has good dispersion. The natural slope angles of the above organomineral fertilizer samples are  $40.7^{\circ}$   $41.8^{\circ}$ . The bulk weight of these 2 kinds of organomineral fertilizer samples is 0.621. 0.611 g/sm<sup>3</sup>. respectively. which fully meets the general requirements of production plants.

The hygroscopic points of these samples were as follows: sample 1 – 76%. sample 2 – 74%. As can be seen from these values. the obtained samples of organomineral fertilizers correspond to average atmospheric humidity. but it is recommended to store and transport them in polypropylene bags during storage in the

autumn-winter and winter-spring periods. when the relative humidity is very high.

The new type of organomineral fertilizer samples were analyzed using modern physico-chemical methods and their elemental and mineral contents were studied. CD:B:PF:NFM =100:5:4 ratios of organomineral fertilizer contains 55% SiO<sub>2</sub>. 4% dolomite. 3% potassium chloride. 2% sodium aluminum silicate. 20% potassium aluminum hydrosilicate. 10% calcium strontium silicate. 6% calcium carbonate and calcium magnesium iron. carbonates are present. CD: B:PF:NFM=100:5:5:4 ratios of organomineral fertilizer contains 26% SiO<sub>2</sub>. 5% potassium chloride. 12% sodium calcium aluminum silicate. 26% potassium aluminum hydrosilicate. 21% calcium strontium aluminum silicate. 8% calcium carbonate and 1 % calcium magnesium iron carbonates.

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UDC 678.01

## STUDYING THE STRUCTURE AND PROPERTIES OF POLYPROPYLENE FILLED WITH NITROGEN, PHOSPHORUS, METAL-CONTAINING OLIGOMERS

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**Abstract:** The synthesis of refractory oligomers to protect polymeric materials and structures from fire and various aggressive environments is an urgent task of modern chemistry of high molecular weight compounds. In this regard, the presented article has studied the receipt of heat-resistant and mechanically strong thermoplastic composite materials by filling the polypropylene of nitrogen, phosphorus and metal-containing oligomers. In addition, we investigated the physico-mechanical properties of polypropylene compositions filled with protective oligomers: the fluidity of their melts by viscometry, the strength of the bend by the method of two support bending and shock viscosity by the "Sharpi" method were determined.

In order to obtain compositional material based on PP, the content of nitrogen, phosphorus, metal-containing oligomers changed from 1 to 5 %. The assessment of the rheological properties of filled composites showed that with an increase in the content of these oligomers, the fluidity of the compositions is reduced, but the resulting compositions can be processed by the method of pressure under pressure. The data obtained show that the compositions containing 5% of oligomers in the form of additives are optimal.

The developed materials were studied for flammability by the oxygen index method, and the thermophysical properties were studied by thermogravimetric and differential thermal analysis (TG and DTA).

It has been established that compounds containing metal, nitrogen and phosphorus have a synergistic effect when used together as fire-fighting additives to polymers. In addition, the performance properties of polymers with such additives are higher than those of compositions containing only phosphorus and nitrogen. The synergism of the nitrogen-phosphorus system is explained by the formation of P-N bonds during thermal decomposition, which promotes phosphorylation of the polymer and enhances the effect of flame retardants as a dehydration catalyst.

**Keywords:** polypropylene, metal-containing oligomers, atomic-powerful microscopy, turnover, strength, bending, shock viscosity, rupture, heat resistance, mixture and composites, functional polymers.

**Introduction.** Upon receipt of polymers for composite materials, the main goal with which fillers are added to them is the improvement of physical, mechanical and heat-physical properties. This can be achieved when the fillers are introduced as fillers, phosphorus, metal-containing oligomers [1].

In the work [2.3], new nitrogen, phosphorus, metal-containing compounds were obtained and proposed as fillers for polymers, on the basis of which more than ten new compositional products were synthesized. Oligomatic antipyrenes based on carbamide, ammophos and metals oxide were also obtained, which increase the heat resistance of polymeric materials [4].

We have already received nitrogen, phosphorus, metal-containing oligomers of brand 17-A [5], which can be used as a filler for polypropylene, determined the thermophysical effectiveness of the compositional material with their use. It is such oligomers, or rather, their physicochemical properties, that are the object of the study in the presented work. Nitrogen, phosphorus and metal-containing oligomers and composites were also studied in detail in the work [6]. The physico-chemical and thermophysical properties have been investigated, and using the atomic power microscope, an analysis of a number of oligomers was analyzed when adding to polymeric materials enhancing heat-resistant properties [7].

**Experimental part.** The object of the study is thermoplastic compositional material (CM) based on polypropylene.

**Determination of the turnover of the melt.** An indicator of the fluidity of the melt (PTR) of thermoplasts is its current speed (melt index). It is defined as the mass of a substance in grams passing through a standard nozzle for 10 minutes at a certain temperature and load. The value of the ATR is a single point on the flow

curve. This indicator is the only standardized rheological characteristic of the melt. Currently, this method of measuring melt fluidity is mentioned in a large number of sources: articles, dissertations and manuals, for example in [8]. A quantitative guideline for pipe manufacturers is usually the melt flow index (ATR) indicated in certificates, which serves as an estimate of the viscosity of the melt at a selected temperature and average molecular weight.

The fluidity index of the melt of polyethylene and compositions based on it was determined on a capillary viscometer of constant shear stresses of the IIRT-M type according to GOST [9] under the following conditions:

Capillary length  $L = 8 \cdot 10^{-3}$  m, diameter  $D = 2,09 \cdot 10^{-3}$  m.

Temperature 170, 190, 210  $\pm 0,5$  °C

Load 2,16; 5; 7,7 kg

The time of heating the material - 5 minutes.

The turnover of the melt is calculated by the formula:

$$PTR = 600 \cdot G/t, \text{ g}/10 \text{ min},$$

where  $G$  is the mass of the bar, g;  $t$  is the period of time between the sequential cutting of the rods, sec.

Having determined the fluidity indicator, we built graphs of its dependence on temperature, load and concentration of additives.

**Determination of the strength of the samples during deformation for bending.** The determination of the strength of the composites during the bend was carried out in accordance with GOST 4648-71 [10] by double-bearing bending. Samples in the form of bars of 55.5 x 6 x 4 mm were subjected to tests at an interdort of 40 mm. The limit of the bend was calculated by the equation:  $\sigma_u = 1,5 (Pa)/(bc^2)$ ,

where  $\sigma_u$  – limit of strength during bending (destructive voltage);  $a$  - interdortion distance;  $b$ ,  $c$  - width and

thickness of the sample, respectively, P is the value of the attached load. The strength values during the bend were defined as the average of ten experiments conducted for each sample.

#### Determination of shock viscosity

**of samples by "Sharpi".** In this work, t shock viscosity according to the "Sharpi" (UVS) was determined in accordance with GOST-4647-80 [11]. Shock viscosity along the "Sharpi" was calculated by the equation:  $a_n = A_n/(ab)$ , where  $a_n$  – shock viscosity along "Sharpi";  $A_n$  – spent energy of the impact on the destruction of the sample without a cut; A, B is the width and thickness in the middle of the sample. The values of the shock viscosity according to the "Sharpi" were defined as the average of the ten experiments conducted for each sample.

**Determination of the strength characteristics of composite materials at rupture.** The stress and relative elongation of the sample corresponding to its rupture were determined according to GOST 14236-81 [12]. These parameters were determined on a tensile testing machine at a deformation rate of 50 mm/min for a blade-shaped sample with geometric parameters of 50 x 6 x 4 mm. The tensile strength of the samples ( $\sigma_p$ ) was determined in accordance with the equation:  $\sigma_p = P/(a \cdot b)$ ,

where P – load; a, b – thickness and width of the sample in the narrowest part, mm

Elongation at break ( $\varepsilon_p$ ) was determined by noting the initial length of the sample ( $L_0$ ) and the increase in the length of the sample at the moment of its failure ( $\Delta L$ ) in accordance with the equation  $\varepsilon_p = (\Delta L/L_0)100\%$ .

**Rheological studies and determination of the activation energy of viscous flow.** Flow curves were obtained on an IIRT-M viscometer. As is known, for non-Newtonian fluids the Ostwald–Weil law is satisfied, relating shear stress ( $\tau$ ) to the rate of development

of shear strain ( $\gamma$ ):  $\tau = \eta \gamma^n$ , where  $\eta$  – viscosity; n – exponent.

After taking the logarithm of the Ostwald–Weil law, we obtain the dependence:  $\ln \tau = \ln \eta + n \ln \gamma$ , which is linear in the coordinates " $\ln \tau - \ln \gamma$ ", which 91 ows us to determine the viscosity from the segment on the ordinate axis, and from the tangent of the slope of the straight line - the exponent n.

However, the Ostwald–Weil equation is almost never satisfied for polymer melts, since the value of the melt viscosity depends on the magnitude of the shear stress. Therefore, they usually resort to constructing flow curves, i.e. dependencies of the type  $\ln \gamma = f(\ln \tau)$  and determining the effective viscosity at each point according to the equation:  $\ln \eta = \ln \tau - \ln \gamma$ .

The values of shear stress and shear rate are calculated directly from the experimental results. Shear stress is calculated using the equation:  $\tau = F/(2SkL)$ , where Sk is the area of the working chamber ( $Sk = 0,715 \cdot 10^{-4} \text{ m}^2$ ); L, r – capillary length and radius ( $L = 8 \text{ mm}$ ;  $r = 1,045 \text{ mm}$ ); F – applied pushing force.

The rate of development of shear deformation can be calculated based on measuring the flow rate of the composite melt:  $Q = \pi R^2 V$ , where V is the speed of movement of the piston; R – chamber radius ( $R = 5 \text{ mm}$ ) according to the equation  $\gamma = Q/(\pi r^2)$ .

The activation energy of viscous flow was determined from the Eyring equation for viscosity:  $\eta = A \exp(E/RT)$ ,

where A is the pre-exponential factor; E – activation energy of viscous flow; R – universal gas constant ( $8,134 \text{ J/mol K}$ ); T – temperature.

Taking the logarithm of the Eyring equation, we obtain:  $\ln \eta = \ln A + E/RT$ .

This dependence is linear in the coordinates " $\ln \eta - 1/T$ ", and from the tangent of the straight line slope the activation energy of the viscous flow  $E = Rtg\alpha$  can be calculated.

When determining the activation energy of viscous flow, the viscosity

dependences were obtained at temperatures from 170 to 210 °C every 20 degrees.

#### Determination of heat resistance of samples according to Vicat.

These tests determine the temperature at which the plastic begins to rapidly soften. A rour 92 flat-ended needle having a cross-sector... area of 1 mm<sup>2</sup> is inserted into the surface of a plastic test piece under a specified load and the temperature is increased at a uniform rate. Vicat heat resistance (softening point) is the temperature at which needle penetration reaches 1 mm. In this work, the Vicat heat resistance of samples was determined in accordance with GOST 15088-83 [13].

#### Differential scanning calorimetry.

Differential scanning calorimetry (DSC) is a technique used to study the behavior of polymers when heated. DSC can be used to study crystalline polymer melting or glass transition. The DSC setup consists of a measuring chamber and a computer. The two cups are heated in the measuring chamber. The first cup contains the material under study, and the second, as a rule, is empty and is used as a standard. A computer is used to control the temperature and regulates the rate at which the temperature of the cups changes. Typical heating rate is about 10° C/min. In this work, we used a Netzsch Simultaneous Analyzer STA 409 PG DSC instrument (Germany), with a K-type thermocouple (Low RG Silver) and aluminum crucibles. All measurements were carried out in an inert nitrogen atmosphere with a nitrogen flow rate of 50 ml/min. The temperature range of measurements was 25-370°C, the heating rate was 5 K/min. The amount of sample per measurement is 5-10 mg. The measuring system was calibrated with a standard set of substances KNO<sub>3</sub>, In, Bi, Sn, Zn.

The degree of crystallinity of the samples is determined using the following equation:  $\alpha = (\Delta H / \Delta H_{st}) \cdot 100\%$ ,

where the term  $\Delta H_{st}$  is a standard value that represents the heat of fusion of a 100% crystalline polymer (293 J/g for PP).  $\Delta H$  is the heat of melting of the sample under study.

#### X-ray phase analysis (XRF).

X-ray phase analysis is a method for quantitative and qualitative determination of the phase composition of crystalline samples, based on the study of X-ray diffraction. Different phases give diffraction patterns that differ from each other, recorded by photomethod or diffractometry. The diffraction pattern of a polyphase sample is the sum of the diffraction patterns of the individual phases. With qualitative X-ray diffraction of fillers and compositions, the angles  $\theta$  are calculated from the position of the diffraction peak, the interplanar distance  $d$  is determined and compared with known values for individual phases using the Wulff-Bragg equation:

$$2d \sin \theta = \lambda n ,$$

where  $d$  is the basal distance, nm;  $\lambda$ —X-ray wavelength, nm.

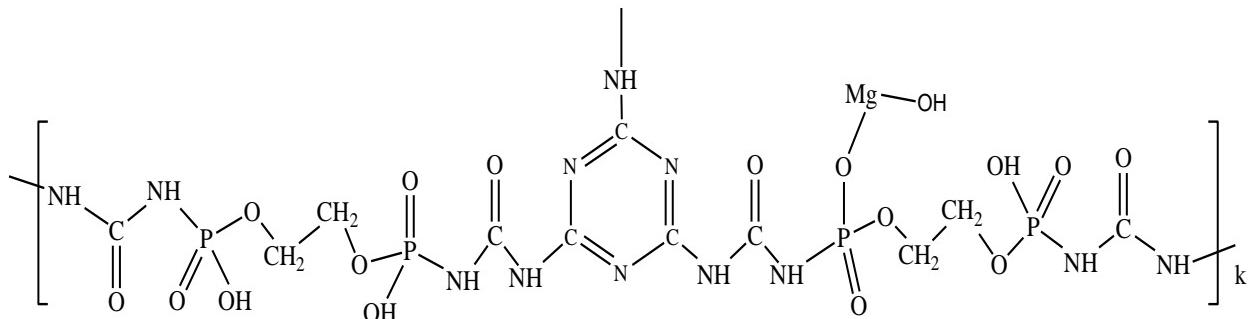
Identification of samples was carried out on the basis of diffraction patterns, which were recorded on an XRD-6100 apparatus (Shimadzu, Japan), controlled by a computer. CuK $\alpha$  radiation was used ( $\beta$ -filter, Ni, 1.54178 tube current and voltage mode 30 mA, 30 kV) and a constant detector rotation speed of 4 deg/min with a step of 0.02 deg ( $\omega/2\theta$  coupling), and the scanning angle was varied from 4 to 80°.

**Study of the structure of composite materials using IR spectroscopy.** IR spectra (device SHIMADZU IRAFFINITI-1, Japan) were taken from films of composite samples with a thickness of about 10  $\mu$ m.

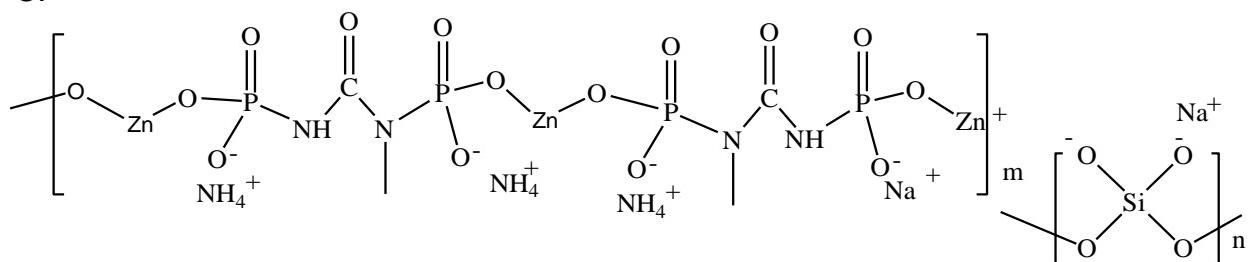
**The synthesis of oligomeric additives** was carried out in the following way:

To obtain oligomers, the reaction was carried out at pH 8-9, between urea dihydrogen phosphate (UHPA), ethylene glycol (EG), melamine (M), magnesium oxide (OM) in a ratio of 2:1:0.5:0.5 and at 165- 170 °C. We conventionally called the

additive to polymers obtained in this way DKEMM. The structure of this additive, which is an oligomeric compound by chemical nature, can be represented as follows:



The second additive, conventionally called **FCMC**, is obtained from ammonium phosphate, urea, sodium metasilicate and zinc oxide at a ratio of 2:1:0.5:0.5 and 165-170 °C:



The synthesis of these additives is described in more detail in [4,5].

The synthesis of oligomeric additives was carried out in the following way:

The calculated amount of amidophosphate (or ammonium phosphate) and ethylene glycol (or urea) was loaded into a flask equipped with a mechanical stirrer, thermometer and reflux condenser, stirred at 100-120 °C for 0.5-1 hour while distilling off water, then added calculated amount of melamine (or sodium metasilicate) and magnesium oxide (or zinc oxide) at 110-130 °C and incubated for 1 hour at 165-170 °C. The resulting oligomeric compounds [4,5] are dark yellow viscous masses.

**Results and discussion.** In this work, using the method of extrusion of the obtained oligomers, composite materials were obtained directly during compounding. The results obtained are shown in Table No. 1.

Table 1  
**Physico-mechanical properties of polypropylene filled with nitrogen-, phosphorus- and metal-containing oligomers**

Parameters	ПП	ПП+5 % DKEMM	ПП+ 5% 17-A	ПП+5% FCMC
Density, g/cm <sup>3</sup>	0,9	0,99	0,99	0,99
Modulus of elasticity, kg/mm <sup>2</sup>	0.18	0.190	0.185	<b>0.206</b>
Deformation, %	250	285	300	<b>300</b>
Elastic force, kgf	24	21.28	20.31	<b>19.80</b>
Tensile strength, kgf	0,17	19.03	19.12	<b>19.31</b>
burning rate	45	≤40	≤40	≤40
UL-94 mm				

Analysis of the results shows that the introduction of nitrogen-, phosphorus-, and metal-containing oligomers into the polymer

improves the thermophysical and physical-mechanical properties of polypropylene. It is worth noting that it was previously

established that the use of nitrogen-, phosphorus-, and metal-containing oligomers as fillers contributes to a significant increase in the heat resistance and physical and mechanical properties of the original polypropylene [14-16].

Thus, to increase the thermophysical and physical-mechanical properties of polypropylene filled with nitrogen-, phosphorus- and metal-containing oligomers, the maximum effect is observed when using the FCMC oligomer. The results obtained show that the use of nitrogen-, phosphorus- and metal-containing oligomers as fillers allows increasing the strength and heat resistance of polypropylene.

To clarify the question of why the properties of the polymer are improved, the IR spectra of the FCMC samples were determined (Figure 1). On the IR spectrum in the regions of 2850-1470 cm<sup>-1</sup> there are absorption bands confirming the presence of -CH<sub>2</sub>- groups, absorption bands corresponding to =CH-groups in the regions of 2987 cm<sup>-1</sup>, and absorption bands in the regions of 2892 corresponding to =CH<sub>2</sub>-groups. Absorption bands in the regions of 2000 and 2800 cm<sup>-1</sup> confirm the presence of -NH groups. The presence of Si-O- groups in the range of 1000–1100 cm<sup>-1</sup> is confirmed by the intense band of –Si-O- groups in the range of 880-870 cm<sup>-1</sup>. In addition, narrow low-intensity bands containing bonds of a halogen-containing compound appear on IR spectroscopy in the regions of 400-700 cm<sup>-1</sup>. In particular, the band at 3595 cm<sup>-1</sup> can be attributed to the stretching vibrations of hydroxyl groups on the surface.

Thus, it can be assumed that polar oxygen-containing fragments formed on the surface of fillers can participate in the adsorption interaction with the polyethylene matrix, which may lead to an improvement in some properties of PP-based nanocomposites.

AFM (atomic force microscopy) is widely used to study the topography and microstructure of the surface of various materials. This method is very sensitive to

pixels and can form the surface of a sample obtained in the nanoscale range, on a three-dimensional surface. AFM data show changes in the size, shape, surface of particles and mechanical properties of materials on the surface using a processing program [17,18].

An important issue is to study the effect of modification by nitrogen-, phosphorus- and metal-containing oligomers on the morphology of the polypropylene surface. The study and analysis of the surface of modified polypropylene shows the distribution of nitrogen, phosphorus and metal-containing oligomers between polymer macromolecules and their interaction. The results were obtained for a polymer composite material obtained from a reaction mixture of polypropylene with 5% DKEMM additive. The analysis was carried out at the AFM (Scientific Research Institute of Chemistry and Physics of Polymers) using silicon cantilevers with a needle turning radius of 10 nm.

The size of the scanned area ranged from 1 to 50 microns. Microscopy was performed in the air by a semi-contact method, when recording changes in the amplitude of the oscillation of the counter arrow, which indicates the topography of the surface and fluctuations in interphase motion (phase detection), showing the adhesion of local surfaces to each other.

Figure 2 shows the surface of polypropylene modified with nitrogen-, phosphorus-, metal-containing oligomers PP+5% DKEMM. It can be seen that the surface roughness of pure polypropylene is 100 nm, the surface roughness of PP +5% DKEMM is 210 nm.

Figure 3 shows the surface of polypropylene modified with PP+5% FCMC. It can be seen that the surface roughness of pure polypropylene is 100 nm, PP+5% FCMC is 212 nm.

Further, on the basis of thermoanalytical studies, we studied the thermo-oxidative properties of the obtained composite materials. It is known that

polymer composite materials filled with nanocomposites with nitrogen, phosphorus, and metal-containing oligomers decompose at higher temperatures than pure polymers, and this decomposition is characterized by the formation of an ash residue [19-20]. This indicates the thermal stability of the resulting composite materials. The complex physical and mechanical properties of composite materials are determined on the basis of chemical changes in the composition of polymers during their processing. These processes

take place at high temperatures. Therefore, in this work, thermal and thermophysical properties were studied: change in melting point, heat resistance.

The melting point and crystallization rate of polymer composite materials were determined by differential scanning calorimetry (DSC) [21-23].

Thermograms of samples filled with fillers were obtained to determine the range of operating temperatures of polymers by differential scanning calorimetry (DSC).

The results are presented in Tables 2 and 3.

**Table 2**  
**Thermodynamic properties of composite materials based on PP+5 % DKEMM**

Compound of the composition	Start of melting, T°C	Melting Peak, T°C	Enthalpy, ΔH, J/g	Degree of crystallinity α, %
PP	160	224	188	55
PP+1 % DKEMM	186	241	197	61
PP+3 % DKEMM	197	243	203	59
PP+5 % DKEMM	209	245	210	58

**Table 3**  
**Thermodynamic properties of composite materials based on PP + 5% FCMC**

Compound of the composition	Start of melting, T°C	Melting Peak, T°C	Enthalpy, ΔH, J/g	Degree of crystallinity α, %
PP	160	224	188	55
PP+1 % DKEMM	189	241	197	61
PP+3 % DKEMM	195	243	203	59
PP+5 % DKEMM	211	245	210	58

A comparative analysis of the diffraction spectra of composite materials by type of fillers and polymers showed that the greater the interlayer distance of the modified fillers and the higher the concentration of the filler, the higher the diffusion rate of the filler included in the composition. Thus, the degree of dispersion of metal oxides in a polymer composition also depends on the duration of mixing of the components and the viscosity of the melt. Accurate results can be obtained by experimentally studying the size and shape of particles using X-ray phase

analysis methods (Debye-Scherrer method). The size of coherent distribution zones (CDZ) (size of nanocrystals) is determined by the Debye-Scherrer formula:  $D_p = K \lambda / (B \cos \theta)$

$D_p$  - Average crystal size (nm)  $K$  - Scherrer constant.  $K$  varies from 0.68 to 2.08. For spherical crystals with cubic symmetry  $K = 0.94$ .  $\lambda$  is the wavelength of x-rays.  $Cu Ka = 1.54178 \text{ \AA}$ .

$B$  is the integral length of reflections in the FWHM diffractometer (full width at half

maximum).  $\cos\theta$  - cosine angle of X-ray diffraction (Table 4, 5).

Table 4

**Results of calculating the size of composite nanoparticles based on PP+5% DKEMM according to the Debye-Scherrer formula**

Nº	2theta- Scanning Angle	FWHM- integral reflection width	D <sub>p</sub> (nm) average crystallite size	D <sub>p</sub> (nm) average
1	8.2	0.478	17.42	
2	8.7	0.57	14.61	
3	21.3030	0.5584	15.12	15.61
4	24.0203	0.54	15.70	
5	26.2200	0.56	15.23	

Table 5

**Results of calculating the size of nanoparticles of a composite based on PP + 5% FCMC using the Debye-Scherrer formula**

Nº	2theta- Scanning Angle	FWHM- integral reflection width	D <sub>p</sub> (nm) average crystallite size	D <sub>p</sub> (nm) average
1	6.025	0.3461	24.03	
2	8.5571	0.4642	17.94	
3	12.212	0.3481	23.99	
4	24.8731	0.2868	29.65	
5	26.459	0.3871	22.04	23.53

Based on the results of X-ray phase analysis, it was established that the particle size in the resulting composite materials is on the nanoscale.

### Conclusions

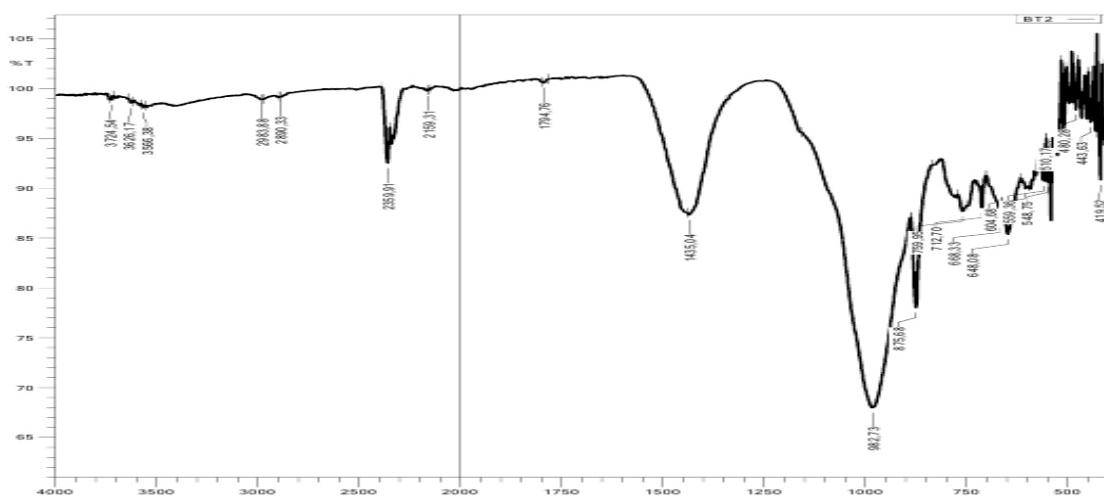
1. An increase in physicomechanical (elastic modulus, deformation, elastic force, tensile strength) and thermophysical properties (burning rate) of polypropylene filled with nitrogen-, phosphorus- and metal-containing oligomers has been established.

2. It has been established that the maximum improvement in physical and mechanical properties is observed when using PP + 5% FCMC.

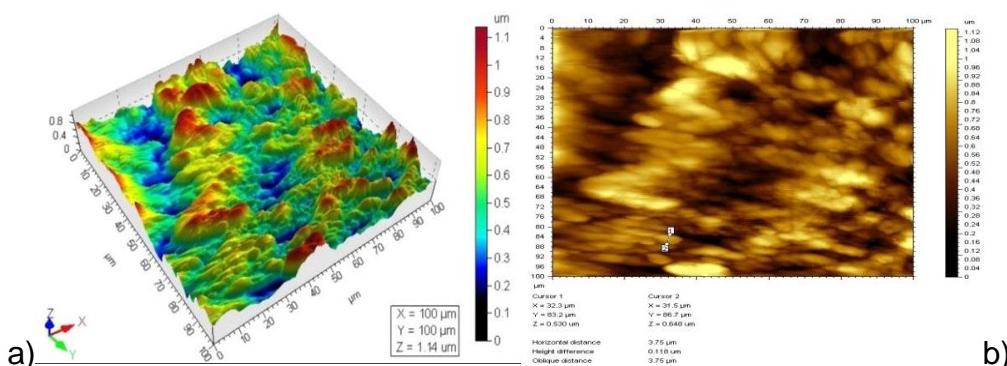
3. It is assumed that the obtained result can be explained by obstacles from nitrogen-, phosphorus- and metal-containing oligomers, which have high intrinsic strength and rigidity.

4. The phase structure of polypropylene modified with nitrogen-, phosphorus- and metal-containing oligomers can be explained by strong adhesion between the matrix and oligomers, which leads to the formation of new adsorption layers at the interface and junctions of amorphous components.

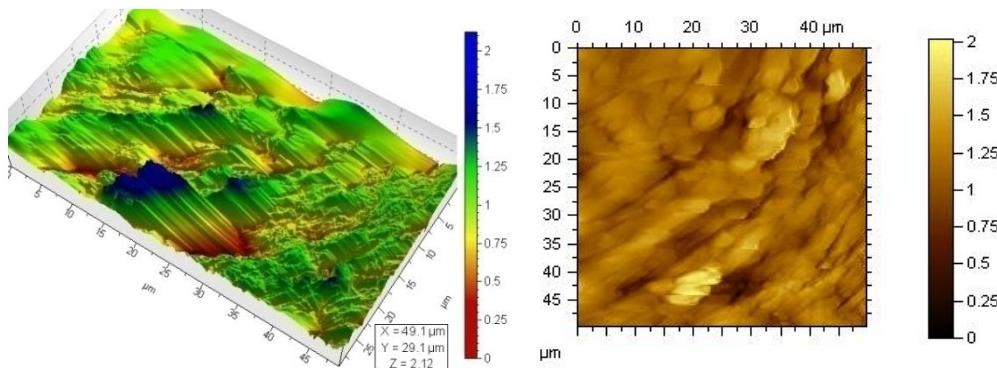
5. Modification of the polymer surface with nitrogen-, phosphorus- and metal-containing oligomers leads to an increase in the degree of flammability on its surface.



**Figure 1. IR spectrum of PP+5% FCMC compositions**



**Figure 2. PP+5% DKEMM: a) - three-dimensional image, b) two-dimensional image**



**Figure 3. PP+5% FCMC: a) - three-dimensional image, b) - two-dimensional image**

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## OPTIMIZATION OF THE METHOD FOR INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS (INAA) OF NATURAL OBJECTS

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**Abstract.** Experimentally, optimization of the time modes of neutron activation analysis of samples of natural media was carried out, based on the nuclear physical characteristics of the studied and "interfering" radionuclides. The detection limit and accuracy of element determination were chosen as a criterion for optimizing the method.

**Keywords:** neutron activation analysis, optimization of time modes, limit of determination, gamma radiation, gamma spectrometry, half-life, radionuclide activity, element isotope, analysis error, radioactive decay, analytical peak, statistical error, photo peak area, "interfering" radionuclides.

**Introduction.** Modern problems of ecology, as well as control and protection of the environment, require a comprehensive study of the content, distribution, distribution, accumulation, forms of occurrence and migration of elements in atmospheric air, sediments, natural and waste waters, soils and other natural objects [1].

When solving the problem of control and protection of the natural environment by physical and chemical methods, it is necessary to determine 50-60 elements, with a detection limit of 10-7-10-14 g, with samples of 0.1-1.0 g. Among the analytical methods, nuclear -physical methods and mainly neutron activation analysis (NAA), characterized by a low detection limit, multiple elements and high productivity.

Currently, there are a number of works on optimization of temporary modes of INAA [2], where multiple irradiation, "cooling" and measurement are proposed. In our case, it was necessary to conduct a highly sensitive mass analysis for a certain number of toxic anthropogenic and natural

elements in a large number of samples. It should be emphasized that thanks to the automation of the aerosol sampling process, we were able to collect relatively high samples on the filters, which in turn influenced the INAA methodology for atmospheric aerosols, namely, the measurement time of long-lived isotopes was reduced by 2.5-3 times, with an increase in the number of elements being determined and reducing the analysis error.

**Materials.** Using the example of the analysis of atmospheric aerosols, we will consider the optimal INAA scheme. The task of optimizing the time modes of analysis is to identify such conditions for conducting INAA that ensure the simultaneous determination of the content of the maximum number of elements with the smallest error. Methods for optimizing the INAA of natural samples are reduced to the study of certain functions and are based on solving the equation of the following form:

$$a = f(\bar{x}, \bar{p}, \bar{q}) \quad (1)$$

where,  $a$  is the optimization function (detection limit, error, etc.);

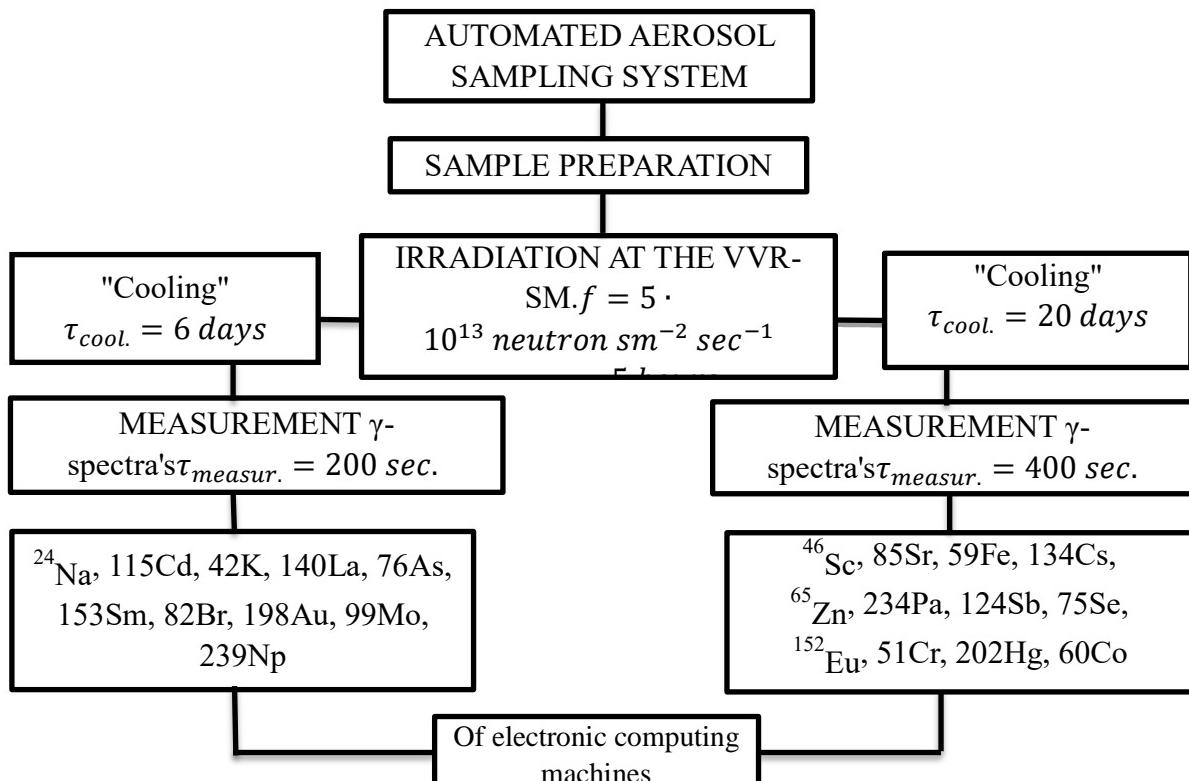
$\bar{x}$  - a set of optimized parameters - factors (irradiation, cooling and measurement time);

$\bar{p}$  - a set of nuclear-physical data determined by the sample matrix (mass of isotopes, their atomic weights, reaction cross-section, decay constants, etc.);

$\bar{q}$  - a set of characteristics of the analytical complex equipment (intensity of activating radiation, recording efficiency of the equipment, etc.).

As a rule, due to the complex nature of function (1), optimization of analysis conditions is carried out on an electronic computer (computer) or experimentally.

We carried out optimization of the time modes of analysis experimentally, based on the nuclear physical characteristics of the studied and interfering radionuclides. The detection limit and accuracy of element determination were chosen as optimization criteria for INAA. The proposed optimal INAA scheme using atmospheric aerosols as an example is presented in Fig. 1.



**Fig.1. INAA scheme for urban atmospheric aerosols**

The determination of Mo, Sm, Au and As in soils and the dissolved phase of water is difficult due to the "interfering" activity of  $^{24}\text{Na}$  and  $^{82}\text{Br}$ . To increase the sensitivity and accuracy of determining these elements, we resorted to varying the neutron spectrum. It is known that the activation cross section of some elements has a resonant character in the above-thermal region of the neutron spectrum [2].

When irradiated in a nuclear reactor, using a cadmium filter, the flux of thermal neutrons at the location of the sample is suppressed and activation will be carried out by resonant neutrons of a wide spectrum of energy. The determination of these elements was carried out by irradiating the test sample in a cadmium channel for 5 hours in a flow of  $f = 5 \cdot 10^{13}$  neutron  $\text{cm}^{-2} \text{ sec}^{-1}$ . After "cooling" for 6

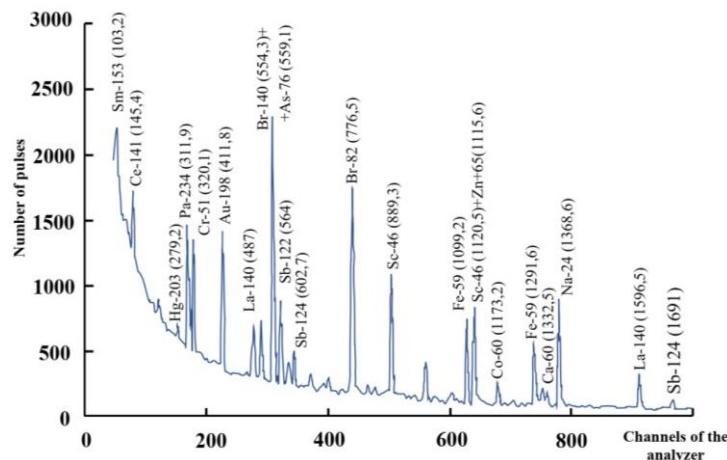
days for medium-lived and 20 days for long-lived radionuclides, measurements were carried out along the corresponding gamma lines on an installation containing two spectrometric paths with Ge(Li) detectors with a volume of 80 cm<sup>3</sup> and an ISKRA-minicomputer. 226 using the SOSNAA program [3], developed by employees of the activation analysis laboratory of the Institute of Nuclear Physics of the Academy of Sciences of the Republic of Uzbekistan. The resolution of the equipment in the region of the 60Co peak (1332.5 keV) was 3.2 keV.

Mathematical processing of the obtained spectrometric information included spectrum smoothing, automatic search for peaks, determination of the areas of photo peaks and background, and calculation of the statistical error of determination.

In Fig. Figures 2-3 show some characteristic gamma spectra of the samples of natural environmental objects

we studied. The overlap of gamma lines of different radionuclides leads to difficulties in interpreting spectroscopic information.

Such difficulties arose in the case of the following pairs of radionuclides: 134Cs - 124Sb, 153Sm - 239U, 65Zn - 46Sc, 203Hg - 75Se, 46Sc - 110mAg and 85Sr - 65Zn. In the first case, we proceeded as follows. Although the 603 keV line has almost one hundred percent yield of gamma quanta for both 134Cs and 124Sb, to determine these radionuclides we used pure lines 796 keV and 1691 keV with lower yields of gamma quanta (30 % and 50 %, respectively), which was quite enough with our samples. In other cases, where the second radionuclide in each pair was interfering with the first, the ratio of the two characteristic lines of the second radionuclide in its standard was used to determine its contribution to the total peak with the first radionuclide in the test sample.



**Fig.2. Gamma spectrum of atmospheric aerosol:**  
tirrad.= 5 hours;  $\tau_{cool.}$  = 6 days;  $\tau_{measur.}$  = 200 sec.

The contribution of the second radionuclide found in this way was subtracted from the indicated peak to determine the contribution of the first.~

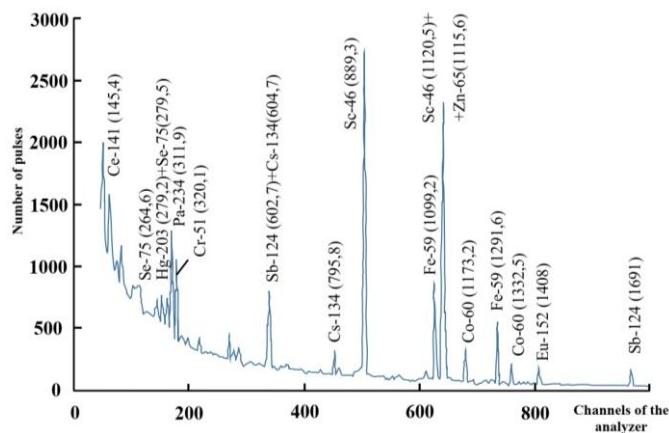
It should be noted that the successful use of INAA in monitoring the quality of the

natural environment requires a comprehensive study and assessment of the influence of various sources of errors, as well as an assessment of the metrology of the developed methods.

The detection limit of INAA elements is defined as [4]

$$C_{min} = \frac{k\sqrt{I_f \cdot C_x}}{I_x} \quad (2)$$

where, is the detection limit of the desired element;  $C_{min}$   
 $C_x$ - content of the element under study in the sample;  
 $I_x$ - useful activity (area under the photo peak) of the element being determined;  
 $I_f$ - interfering activity (base area under the peak);  
 $k$ - confidence factor (3÷10).



**Fig.3. Gamma spectrum of atmospheric aerosol:**  
 Tirrad.= 5hours;  $\tau_{cool.}$  = 20 days;  $\tau_{measur.}$  = 400 sec.

The concentration of elements is determined by the formula:

$$C_{xi} = [I_{06p} \cdot m_{\varTheta T,i}] / [I_{\varTheta T,i} V], \quad (3)$$

where, is the concentration of the i-th element;  $C_{xi}$   
 $I_{06p}$ - area of the analytical peak of the i-th element in the breakdown;  
 $m_{\varTheta T,i}$  - mass of the i-th element in the comparison sample;  
 $I_{\varTheta T,i}$  - area of the analytical peak of the i-th element in the comparison sample;  
 $V$ - volume of water or pumped air or mass of soil.  
 Taking (3) into account, it is easy to show that

$$C_{min} = \frac{k\sqrt{I_f \cdot m_{et}}}{I_{et} \cdot V} \quad (4)$$

A generally accepted way to assess the correctness of a method is to use certified reference materials to assess and control the reproducibility and correctness of analytical results [5].

The similarity of the physicochemical composition of standard samples and the analyzed natural objects results in the same magnitude of contributions to the error made due to the influence of interfering reactions, self-shielding effect, etc. Except in addition, the difference

in the geometric shapes of the standard and the sample is minimal, which also reduces the measurement errors of natural samples. As standard samples for analysis of aerosols, soils, waters and precipitation, certified standard samples SV, SOV1-SOV5 and SP1-SPZ were used.

The discrepancy between our and recommended data averages 5-25%. Long-term and routine analysis of approved domestic and foreign reference materials indicates good reproducibility

and correctness of INAA. The productivity of INAA of natural objects according to the proposed scheme is 500-600 element determinations per shift.

### Conclusions:

- 1) The recommended optimal time regimes ensured the achievement of detection limits comparable to the literature data with a shorter duration of irradiation and "cooling" of samples, which is important in geophysical and environmental studies;
- 2) According to the proposed optimal scheme, the concentrations and forms of occurrence of more than twenty elements in adjacent natural environments are determined with a detection limit of 10-6-10-13 g/g, a relative standard deviation of 0.05-0.25;
- 3) Analysis of the metrological parameters of INAA allows us to conclude that there is a low detection limit, satisfactory reproducibility and accuracy, which favors the use of the method in quality control of various natural environments.

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## ISOTHERM OF AMMONIA ADSORPTION IN ZEOLITE CaA (M-22)

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#### Abstract:

**Objective.** The article presents experimentally obtained values of the adsorption isotherm of ammonia molecules in synthetic zeolite CaA (M-22) at a temperature of 303 K. Isotherm values were measured using an improved microcalorimeter connected to a universal high vacuum apparatus. The

differential values of the free energy were calculated from the equilibrium values of the pressure. In CaA (M-22) zeolite, a regular relationship between the amount of adsorption and energy properties of ammonia molecules, as well as the sorption mechanism from the initial area of adsorption to the area of condensation heat of ammonia and the regularity of ammonia molecules filling the volume of zeolite were determined. Under experimental conditions, the adsorption capacity of this zeolite for ammonia was found to be 10.5 mmol/g in 1 g of zeolite. It was determined that 40% of the total adsorption is sorbed up to the equilibrium pressure of 1 torr, 50% up to 6 torr pressure, 60% up to 24 torr pressure, 65% up to 50 torr pressure and 100% at 467 torr pressure. The adsorption isotherm was recharacterized by the three-state equation of micropore volumetric saturation theory (VMOT) and it was shown that the theoretically calculated values were in perfect agreement with the experimentally obtained values.

**Methods.** The adsorption isotherm was measured with high accuracy (enthalpy 0.2  $\mu$ J, small values of pressure with an accuracy of  $10^{-5}$  torr) and stability using a system consisting of a Tiana-Calve type DAK-1-1A differential automated microcalorimeter connected to a universal high-vacuum device. The adsorption-calorimetric method used in the research allows obtaining molar thermodynamic characteristics, as well as revealing the detailed mechanisms of adsorbent-adsorbate and adsorbate-adsorbate sorption processes. Adsorption measurements and dosage of adsorbate were performed using a high-vacuum adsorption device. The device allows dosing of adsorbate by gas-volume and volume-liquid methods. B627 diaphragm baratron was used to measure the equilibrium pressure up to  $10^{-5} \div 0.8$  torr, U manometer was used to measure the pressures at  $R > 0.8$  torr. The adsorption-calorimetric method allows to study nano-, micro-, mesostructured adsorbents and their surface-active surfaces, to reveal in detail the main thermodynamic properties and mechanisms of adsorption processes in which adsorbents occur.

**Results.** Adsorption of ammonia molecules on CaA (M-22) zeolite at a temperature of 303 K from the area of small saturations to the heat of condensation of ammonia from the initial area to the saturation pressure was found that the enthalpy values of ammonia adsorption in this zeolite are almost 40-50 kJ/mol higher than the adsorption enthalpy of polar and non-polar molecules of different nature. During the adsorption process, it was found that ammonia molecules interact with  $\text{Na}^+$  and  $\text{Ca}^{2+}$  cations in  $\text{S}_1$  and  $\text{S}_{11}$  positions of zeolite.

**Conclusion.** The results of adsorption-calorimetric research obtained on the basis of experience allow to obtain the main thermodynamic functions of the studied systems, which are necessary for the development of theoretical concepts of chemical and physical adsorption in synthetic zeolites of the LTA type, including CaA, as well as in the calculation of sorption technology processes and devices in practice.

**Keywords:** adsorption, enthalpy, free energy, isotherm, pressure, relative pressure, microcalorimeter, ammonia.

**Introduction.** In order to obtain environmentally friendly gas from natural gases, the demand for drying them from water vapor, cleaning them from gases such as hydrogen sulfide, and preventing environmental problems caused by the release of greenhouse gases, including carbon (IV) oxide into the atmosphere, is increasing year by year. For this purpose, synthetically produced zeolites are widely used to avoid the above-mentioned problems. It is important to achieve scientific and practical innovations based on the results of the research conducted on the synthesis of zeolites with high adsorption and catalytic properties, increasing the level of their selectivity.

Today, in the world, the following scientific solutions for the synthesis of nanoporous molecular bubble zeolites for adsorption processes are justified, including: the selection of raw materials

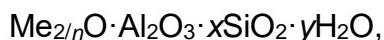
with suitable adsorption properties to obtain zeolites with selective absorption properties; determination of complete thermodynamic properties of synthesized zeolites; formation of ion-molecular complexes in the zeolite matrix, determining the state of localization; studying thermokinetics of adsorption and cation exchange in the zeolite structure, migration of cations; the complete molecular mechanism of zeolite adsorption should be determined.

Aluminum and silicon atoms in aluminosilicate zeolites can be replaced by 3-5 valence elements such as gallium, germanium, phosphorus, which are close to them in nature, and their sorption and catalytic properties can be changed [1]. Another characteristic of these zeolites is the presence of water molecules in the internal structure of the crystal, when heated to a temperature of  $450^\circ\text{C}$ , water

molecules evaporate without breaking the structure of the crystal lattice, and the possibility of ion exchange due to the mobility of alkaline, alkaline earth cations and water molecules in the zeolite [2-4].

Aluminosilicate zeolites with a porous crystal framework structure. The frameworks of zeolites are composed of interconnected tetrahedral  $[SiO_4]$  and  $[AlO_4]$ , the ends of which are connected by oxygen atoms. The unique arrangement of aluminum atoms in the structure is one of

the properties of aluminosilicates. Al and Si atoms are arranged in the tetrahedral coordination position in all aluminosilicates with respect to oxygen and are isomorphically substituted for silicon in the general silicon-oxygen framework. The negative charge of the tetrahedron is neutralized by various alkaline or alkaline earth positive cations located in the zeolite voids. The composition of all synthetic zeolites can be described by the following chemical formula:



where n-metal cation valency, x- $SiO_2/Al_2O_3$  molar ratio, y-number of moles of water.

Based on the structure and composition of the crystal lattice of zeolites, zeolites are characterized by the names of MFI, MOR, FAU, LTA, regardless of their highest symmetry, which can choose sorption properties and catalysis characteristics [5] and their main thermodynamic properties of catalysis and adsorption of polar, non-polar and quadrupole molecules of different nature are fundamentally different from each other [6-11].

MFI, MOR, FAU, LTA and other types of zeolites form adsorbate/adsorbent ion-molecular complexes of different ratios depending on the amount of cations, which are the main adsorptive active centers. For example, in MFI zeolite modification 5 form of sodium cation, the formation of  $8NH_3:Na^+$  ion-molecular complex is formed by ammonia adsorption, and 24 hydrogen molecules form a wrap around sodium cation in the intersection of zeolite channels [12-14].

CaA (M-22), CaA (M-34),  $Ca_5Na_3A$  (MISS 624) and  $Ca_4Na_4A$  (Horst 50/50) zeolites are considered to be the main active centers of  $Ca^{2+}$  and  $Na^+$  cations in A-type zeolites. Also, since the amount of cations is in different proportions, adsorbate plays an important role in the amount of sorption of molecules. By

determining the main thermodynamic characteristics of the adsorption of test molecules such as carbon dioxide, benzene, water and ammonia, the amount, nature and strength of energetically active centers in the same type of crystallographic positions are determined [15-24].

Step change of adsorption enthalpy of water and carbon IV oxide molecules in zeolites of type A (M-22, M-34, MISS-624, Horst 50/50) with alkaline earth and alkaline earth metal cations is the result of stoichiometric interaction with  $Ca^{2+}$  and  $Na^+$  cations. For example, water molecules in  $CaA_1$ ,  $CaA_2$  and  $CaNaA_1$  zeolites contain  $22H_2O/e.c.$ ,  $28H_2O/e.c.$  and  $30H_2O/e.c.$  respectively,  $7CO_2/e.c.$ ,  $6CO_2/e.c.$ ,  $8CO_2/e.c.$  and  $9CO_2/e.c.$  respectively, in  $CaA_1$ ,  $CaA_2$ ,  $CaNaA_1$  and  $CaNaA_2$  zeolites of carbon IV oxide molecules. A stepwise change in the formation of ion-molecular complexes has been determined [15-17, 24].

This article presents the results of adsorption isotherm, as well as the mechanism of adsorption, obtained by the method of adsorption-calorimetric experiment on synthetic zeolite of ammonia  $CaA$  (M-22).

**Methods.** The adsorption-calorimetric method used in this article allows obtaining the basic thermodynamic characteristics with high accuracy and revealing the detailed mechanisms of sorption processes in zeolite. The

experiment was carried out using a universal high-vacuum adsorption device. The device is adapted to measure the amount of adsorbate by both gas-volumetric and liquid-volumetric methods. A modified Tiana-Calve type DAK-1-1A microcalorimeter was used as a microcalorimeter with high accuracy and stability.

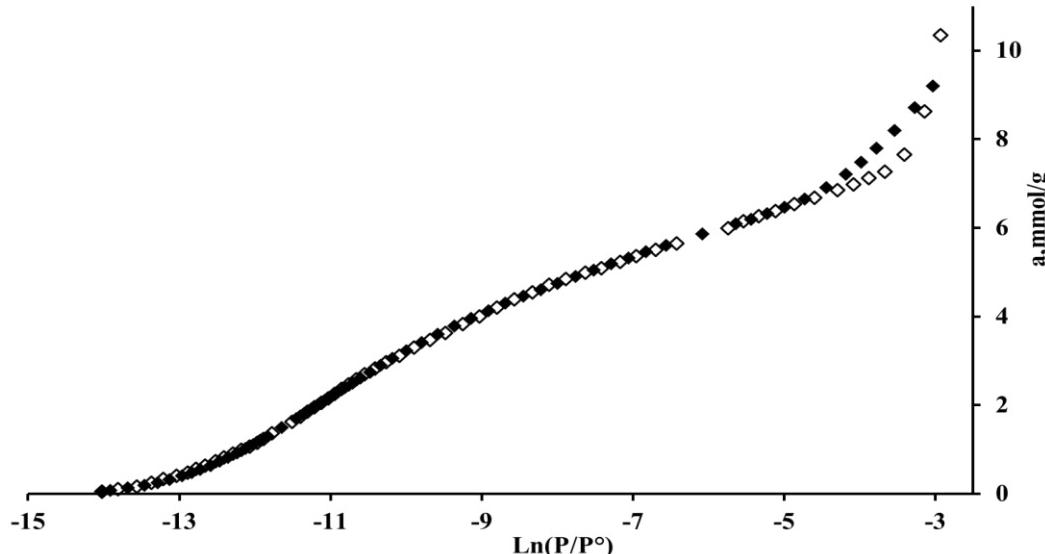
In the adsorption study, the adsorption of ammonia on CaA (M-22) zeolite at 303 K was studied and the adsorption isotherm was fully analyzed. The unit cell composition of this zeolite is  $\text{Ca}_{2,975}\text{Na}_{1,194}(\text{SiO}_2)_{12}(\text{AlO}_2)_{12}$ . Based on its chemical composition, the amount of calcium cations in 1 g of zeolite is 1.89 mmol/g and the amount of sodium cations is 0.76 mmol/g.

**Discussions.** The isotherm of ammonia adsorption on CaA (M-22) zeolite in logarithmic coordinates is presented in Fig. 1. At small saturations of the adsorption volume, the equilibrium relative pressure at the adsorption amount of 0.05 mmol/g is equal to  $P/P_s=8,11 \cdot 10^{-7}$  ( $R=0.00674$  torr). In this case,  $P_s = 8750$  torr represents the saturation pressure of ammonia at a temperature of 303 K. Due to the high relative pressure of ammonia, the

experiment was carried out up to 467 torr. The adsorption isotherm was brought to the adsorption amount of 10.35 mmol/g at a relative pressure of  $P/P_s=0.0534$  (or  $R=467$  torr).

The adsorption isotherm shows that cations in the zeolite matrix are in a strong ion-molecular complex bond with ammonia molecules in the initial region. The isotherm initially moves almost linearly towards the abscissa axis at the adsorption amount of ~0.76 mmol/g up to  $P/P_s=4 \cdot 10^{-6}$  ( $R=0.04$  torr).

Based on the chemical composition of zeolite, the amount of sodium cations is equal to 0.76 mmol/g, that is, at the adsorption amount of ~0.8 mmol/g, ammonia molecules form a  $1\text{NH}_3:\text{Na}^+$  monomer ion-molecular complex with sodium cations in zeolite. The isotherm changes linearly with a partial tilt to  $P/P_s=1 \cdot 10^{-5}$  ( $R=0.088$  torr) ~1.52 mmol/g adsorption of  $2\text{NH}_3:\text{Na}^+$  dimer, 2.3 mmol/g adsorption amount and  $P/P_s=1.76 \cdot 10^{-4}$  ( $R=0.154$  torr) at a relative pressure of  $3\text{NH}_3:\text{Na}^+$  trimer, 3 mmol/g adsorption amount and  $P/P_s=3.5 \cdot 10^{-4}$  ( $R=0.34$  torr) at a relative pressure of  $4\text{NH}_3:\text{Na}^+$  tetramer ion-molecular complex is formed.



**Figure 1. Adsorption isotherm of ammonia at 303 K on CaA (M-22) zeolite. In the ◊-experiment, ◆-values of the general equation of the theory of volumetric saturation of micropores (VMOT)**

The subsequent adsorption isotherm graph of ammonia molecules changes regardless of the amount of sodium cations in the zeolite, which means that the adsorption process in the first coordination sphere with sodium cations of ammonia molecules is completed. This is also confirmed by the relative increase in the equilibrium pressure after the formation of the  $4\text{NH}_3:\text{Na}^+$  tetramer ion-molecular complex.

The regular change of the isotherm in accordance with the zeolite active centers corresponds to the amount of calcium cations, the second active center in its content, ~1.9 mmol/g, that is, ammonia molecules begin to adsorb on  $\text{Ca}^{2+}$  cations. Value of relative pressure  $P/P_s=6 \cdot 10^{-4}$  ( $R=6$  torr) and 5 mmol/g adsorption of  $1\text{NH}_3:\text{Ca}^{2+}$  monomer, amount of adsorption 6.8 mmol/g and relative pressure  $P/P_s=0.0137$  ( $R=120$  torr)  $2\text{NH}_3:\text{Ca}^{2+}$  dimer forms ion-molecular complexes.

At the adsorption enthalpy obtained in the experiment, after the adsorption amount of ~7 mmol/g, the enthalpy decreases to the heat of condensation of ammonia. But the change in differential enthalpy and entropy (above the entropy of liquid ammonia) changes in accordance with the amount of calcium cations in the zeolite and increases sharply, that is, ammonia molecules in the second coordination sphere of calcium cations adsorbate-adsorbate (ammonia-ammonia) with an adsorption amount of 8.7 mmol/g and  $P/P_s=0.05$  ( $R=380$  torr) at a relative pressure of  $\text{Ca}^{2+}:2\text{NH}_3:\text{NH}_3$  complex, the next 1.64 mmol/g ammonia molecules are also 10.52 mmol/g adsorption in the second coordination sphere and  $P/P_s=0.054$  ( $R=467$  torr) at a relative pressure of the sorption process ends by forming a  $\text{Ca}^{2+}:2\text{NH}_3:2\text{NH}_3$  complex.

Ammonia adsorption isotherm on CaA (M-22) zeolite is fully described using the three-state VMOT equation [25]:

$$a = 4.77 \exp[-(A/28.69)^7] + 2.015 \exp[-(A/17.63)^4] + 5.6 \exp[-(A/8.19)^3] \quad (1)$$

where,  $a$  is the adsorption value (mmol/g),  $A = RT \ln P_s / P$  is the free energy and represents the work (kJ/mol) done in transferring the gas to the equilibrium gas phase. From Figure 1, it can be seen that the calculated values in VMOT are in full agreement with the experimentally obtained adsorption amount up to 7 mmol/g. The first two terms of the equation represent the adsorption of ammonia molecules on the active centers of sodium and calcium cations of zeolite. The amount of adsorption in the formation of  $4\text{NH}_3:\text{Na}^+$  and  $1\text{NH}_3:\text{Ca}^{2+}$  is equal to 4.93 mmol/g, which corresponds to the value of  $a_{01}=4.77$  mmol/g of equation 1. The amount of adsorption in the formation of  $4\text{NH}_3:\text{Na}^+$  and  $1\text{NH}_3:\text{Ca}^{2+}$  complexes is equal to 6.82 mmol/g, and the sum of the values of equation 1  $a_{01}=4.77$  mmol/g and  $a_{02}=2.015$  mmol/g fully corresponds to 6.92 mmol/g.

Since the adsorption process follows an exponential equation, the 3rd term of

equation 1 has almost no effect from a small saturation pressure to a relative pressure of  $P/P_s$  ( $R=120$  torr) and is weak. that is, it represents the sorption process resulting from the mutual Waa-der-Waals interaction of the adsorbate molecule in the second coordination sphere.

**Discussions.** The isotherm of ammonia molecules in CaA (M-22) nanostructured zeolite was studied and the free energy values were calculated. Tetramer  $4\text{NH}_3:\text{Na}^+$  in the first coordination sphere with sodium cations in the  $S_I$   $\text{ba}$   $S_{II}$  positions of zeolite, dimer  $2\text{NH}_3:\text{Ca}^{2+}$  ion-molecular complexes with calcium cations in the first coordination sphere, then two ammonia molecules with the initially adsorbed ammonia molecules in the second coordination sphere  $\text{Ca}^{2+}:2\text{NH}_3:2\text{NH}_3$  - was found to form molecular complexes. It was proved that the mechanism based on the coefficients of the adsorption amount obtained on the

basis of the volume theory of micropores fully corresponds to the mechanism based on the values obtained in the experiment. It was found that 65% of the total adsorption

amount up to 50 torr corresponds to the adsorption of sodium and calcium cations, the main active centers of zeolite.

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# RHEOLOGICAL PROPERTIES OF AMMOPHOSPHATE PULPS OBTAINED USING PHOSPHORITE POWDER OF THE KHODJAKUL DEPOSIT

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**Abstract:**

**Objective.** The rheological characteristics (density, viscosity) of acidic and ammoniated phosphate slurries obtained from the decomposition of Khodjakul phosphate powder with extraction phosphoric acid (EPA) in a wide range of acid : phosphorite mass ratio and temperatures were studied. It has been shown that both acidic and ammoniated pulps have high fluidity and can be transported by pumping devices without any restrictions.

**Methods.** Experiments on the decomposition of phosphorite powder (PP) with phosphoric acid were carried out in a tubular glass reactor equipped with a screw stirrer driven by a motor. The required amount of EPA was placed in the reactor and heated to 65°C. Phosphate raw materials were introduced into the reactor with an EPA attachment. The mass ratio of EFA :PP was chosen in the range of 100: (5-30). The density of acid phosphate pulps was determined by the pycnometric method with a measurement accuracy of 0.05 rel. %, and kinematic viscosity - using a glass capillary viscometer VPJ-1 with an error of 0.2 relative to % in the temperature range of 20-90 °C.

**Results.** Laboratory experiments have established that the most optimal mass ratios of EFA :PP is 100:20 and 100:25. Under these conditions, the ammonium phosphate pulp at a temperature of 60°C has a density and viscosity of 1.32-1.34 g/cm<sup>3</sup> and 20.06-24.13 centipoise, respectively.

**Conclusion.** In the range of 20-90°C, the density and viscosity of acid phosphate pulps obtained from the decomposition of phosphorite powder Khojakul with phosphoric acid in a wide range of initial components (EFA :PP = 100:5-30). It is shown that the pulps have high fluidity (no more than 1.37 g/cm<sup>3</sup> and 7.08 centipoise).

**Keywords:** nodular phosphate powder, extraction phosphoric acid, acidic and ammoniated phosphate pulps, density, viscosity.

**Introduction.** There are 25.73 million hectares of agricultural land in Uzbekistan, of which 3.73 million hectares are irrigated [1]. It is on irrigated lands that over 97% of the agricultural products of the republic are obtained.

One of the main problems is the shortage of water resources, which does not allow a sharp increase in the area of irrigated land. Therefore, the chemicalization of agriculture provides for an increase in the production of mineral fertilizers, including phosphorus-containing ones.

In 2018, the chemical industry produced 138.2 thousand tons of phosphoric fertilizers in terms of 100% P<sub>2</sub>O<sub>5</sub>. Whereas, the demand for agriculture was 688.4 thousand tons of phosphoric fertilizers. Based on this situation, it can be seen that the demand is provided only by 20%.

As for the assortment of phosphorus-containing fertilizers, it consists of ammophos (10% N; 46% P<sub>2</sub>O<sub>5</sub>), suprephos-NS (8-15% N; 20-24% P<sub>2</sub>O<sub>5</sub>), PS-Agro (4-6% N; 34-41% P<sub>2</sub>O<sub>5</sub>), feed ammonium phosphate (12% N; 53-55% P<sub>2</sub>O<sub>5</sub>), simple (1.5% N; 13.5% P<sub>2</sub>O<sub>5</sub>) and enriched superphosphate (2.5% N; 18-26% P<sub>2</sub>O<sub>5</sub>) [2]. The main phosphate raw material for their production is washed and calcinated concentrate (26% P<sub>2</sub>O<sub>5</sub>), produced at LLC "Kyzylkum phosphorite complex". The complex annually produces 716 thousand tons of concentrate, processing phosphorite ore (17% P<sub>2</sub>O<sub>5</sub>) of the Kyzylkum deposit. However, the volume of concentrate is not enough for the production of the above-mentioned mineral fertilizers, which makes it necessary to involve other local deposits in the production. Phosphorite manifestations are present in many regions of Uzbekistan. These are Ferghana, Surkhandarya, Pritashkent, Navoi (Penjikent), Central Kyzylkum, Bukhara-Khiva and Karakalpak [3].

There are a number of deposits of nodular phosphorites in Karakalpakstan

such as Khodzhakul, SultanUizdag, Khojeyli, Nazarkhan, Chukai-Tukai, Porlitau, Beshtyube and others [4].

The deposits belong to the carbonate-sandy type, represented by a phosphate mineral with an admixture of clay and carbonate substances with abundant gangues of quartz grains, feldspar, mica, glauconite, zircon and iron hydroxides cemented with carbonate cement [5].

However, these low-grade phosphorites do not meet the requirements for sulfuric acid processing to produce extraction phosphoric acid (EPA) and ammophos. However, they can serve as secondary phosphate raw materials in the production of qualified phosphorus-containing fertilizers.

In the early 80<sup>st</sup> of the last century, specialists of the NGO "Minudobreniya", NGO "NIIHIMMASH", NIUIF, Mendeleev Moscow Art Institute developed the technology of nitrogen-phosphorus fertilizer-ammonium phosphate [6, 7]. Its production was mastered from Karatau phosphorites at the Dzhambul superphosphate plant in Kazakhstan, at the Chardzhou chemical plant in Turkmenistan, at Almalyk JSC "Ammophos" (now JSC "Ammophos-Maxam"), from apatite concentrate at the Balakovo "Mineral Fertilizers" in Russia. An important advantage of ammonium phosphate is the possibility of using almost any kind of phosphate raw materials.

The process of obtaining ammonium phosphate has also been studied on the example of various grades of phosphorites of Central Kyzylkums (phosphorite powder, thermoconcentrate, chemically enriched concentrate, pulverized fraction) [8]. At the same time, the mass ratio of EPA : PP is taken in the range of 100:(5-30).

However, there is no information in the literature about the use of nodular phosphorites of Karakalpakstan in ammophosphate fertilizer technology. In this connection, in this work, the process of decomposition of phosphate rock from the Khodzhakul deposit with extraction

phosphoric acid was carried out and the rheological properties of acidic and ammoniated phosphate pulps were studied.

**Research methods.** For the experiments, phosphate rock from the Khodzhakul deposit was used as feedstock, composition (wt. %):  $P_2O_5$  – 19.11;  $P_2O_5$  acceptable by citric acid:  $P_2O_5$  general. = 63.26;  $P_2O_5$  acceptable. :  $P_2O_5$  general. = 35.85;  $CaO$  – 32.83;  $MgO$  – 0.30;  $CO_2$  – 4.03;  $Fe_2O_3$  – 3.50;  $Al_2O_3$  – 1.54;  $SO_3$  – 1.10; F – 1.58;  $SiO_2$  – 28.0; insoluble residue. – 1.64;  $H_2O$  – 2.62;  $CaO_{total}$ . :  $P_2O_5_{total}$ . = 1.72, extraction phosphoric acid (EPA) produced by JSC "Ammophos-Maxam" composition, mass%: 14.65  $P_2O_5$ ; 0.43  $CaO$ ; 0.57  $MgO$ ; 0.23  $Fe_2O_3$ ; 0.26  $Al_2O_3$ ; 0.73 F; 1.33  $SO_3$ ,  $p = 1.20 \text{ g/cm}^3$  and gaseous ammonia (100%  $NH_3$ ). The dispersion of phosphorites is characterized as follows: class (-5+3) – 7.65%; (-3+2) – 24.43%; (-2+1 mm) – 18.29%; (-1+0.5 mm) – 3.0%; (-0.5+0.25 mm) – 22.73%; (-0.25+0.16 mm) – 10.07%; (-0.16+0.1 mm) – 4.11%; (-0.1+0.05 mm) – 6.20%; (-0.05 mm) – 3.51%.

Experiments on the decomposition of phosphorite powder (PP) with phosphoric acid were carried out in a tubular glass reactor equipped with a screw stirrer driven by a motor. The required amount of EPA was placed in the reactor and heated to 65°C. Phosphate raw materials were introduced into the reactor with an EPA attachment. The mass ratio of EPA : PP was chosen in the range of 100: (5-30). The duration of the decomposition process from the end of the loading of the raw material is 45 minutes. After that, the density and viscosity of the pulps were measured depending on the mass ratio of EPA: PP

and temperature. The density of acid phosphate pulps was determined by the pycnometric method with a measurement accuracy of 0.05 relative to %, and the kinematic viscosity was determined using a glass capillary viscometer VPJ-1 with an error of 0.2 relative to % in the temperature range of 20-90°C. The results of the experiments are summarized in tables 1 and 2.

**Results and discussion.** As can be seen from the data in tables 1 and 2, both an increase in the proportion of phosphorite and an increase in temperature have a noticeable effect on the density and viscosity of the pulp. Thus, an increase in the proportion of phosphorite in the system from 100:5 to 100:30 at 20°C leads to an increase in pulp density from 1.2104 to 1.370  $\text{g/cm}^3$ , that is 1.13 times, at 60°C from 1.1857 to 1.2714  $\text{g/cm}^3$ , or 1.07 times, and at 90°C from 1.1698 to 1.2124  $\text{g/cm}^3$ , or 1.04 times (table 1). An increase in pulp temperature from 20 to 90°C, depending on the EPA:PP ratio, contributes to a decrease in density.

For example, with EPA:PP = 100:10 this indicator decreases from 1.2253 to 1.1835  $\text{g/cm}^3$ , EPA:PP = 100:20 from 1.2559 to 1.2062  $\text{g/cm}^3$  and at EPA:PP = 100:30 from 1.370 to 1.2124  $\text{g/cm}^3$ , that is. in 1.036, 1.04 and 1.13 times, respectively.

Table 2 shows that at a temperature of 20°C, the increase in the mass ratio of EPA:PP from 100 : 5 to 100 : 30 leads to an increase in viscosity from 3.28 to 7.08 centipoise, at 50°C from 2.03 to 3.79 centipoise, at 70°C from 1.68 to 2.89 centipoise and at 90°C from 1.52 to 2.68 centipoise, that is, 2.16, 1.87, 1.72 and 1.76 times, respectively.

Table 1  
**Density of acid phosphate pulps based on phosphoric acid decomposition of Khodzhakul phosphorite powder**

Temperature, °C	Density ( $\text{g/sm}^3$ ) at EPA:PP mass ratios					
	100:5	100:10	100:15	100:20	100:25	100:30
20	1.2104	1.2253	1.2403	1.2559	1.3123	1.370
30	1.2041	1.219	1.2331	1.2479	1.2949	1.3418

40	1.1979	1.2127	1.2237	1.2389	1.2779	1.3186
50	1.1918	1.2065	1.2144	1.230	1.2626	1.2961
60	1.1857	1.2004	1.2068	1.2234	1.2488	1.2714
70	1.1809	1.1943	1.2011	1.2168	1.2353	1.2506
80	1.1761	1.1895	1.1963	1.2115	1.221	1.2298
90	1.1698	1.1835	1.1907	1.2062	1.2092	1.2124

Table 2

**Viscosity of acid phosphate pulps based on phosphoric acid decomposition of Khodzhakul phosphorite powder**

Temperature, °C	Viscosity (centipoise) at EPA:PP mass ratios					
	100:5	100:10	100:15	100:20	100:25	100:30
20	3.28	3.99	4.70	5.43	6.26	7.08
30	2.69	3.28	3.88	4.34	5.04	5.78
40	2.29	2.74	3.19	3.52	3.98	4.54
50	2.03	2.36	2.71	2.96	3.31	3.79
60	1.82	2.10	2.37	2.58	2.93	3.22
70	1.68	1.89	2.12	2.33	2.66	2.89
80	1.58	1.77	1.96	2.15	2.44	2.73
90	1.52	1.66	1.80	2.00	2.34	2.68

An increase in temperature from 20 to 90°C at EPA:PP ratios = 100:10, 100:20 and 100:30 contributes to a decrease in pulp viscosity by 2.40, 2.72 and 2.64 centipoise, respectively.

Thus, at the studied intervals of technological parameters, the values of the density and viscosity of the phosphoric acid pulp indicate that it has a high fluidity and can be transported by pumping devices without any restrictions.

According to the current technology of production of ammonium phosphate, acid phosphate pulp with a pH value of 2.0-2.5 and a moisture content of more than 60% is ammoniated to pH = 4.0-4.5 and then

evaporated to a humidity of 35-40%, after which it is fed for granulation into a drum granulator dryer (BGS).

Based on this, acid phosphate pulps were neutralized with ammonia gas in a special reactor with intensive stirring to pH values = 4.0-4.5.

The pH value of the ammoniated pulps was measured using a laboratory ionomer of the I-130M brand with an electrode system of electrodes ESL 63-07, EVL-1M3.1 and TKA-7 with an accuracy of 0.05 pH units. The results of measuring the density and viscosity of ammoniated phosphate pulps are shown in tables 3 and 4.

Table 3

**Density of ammoniated phosphate pulps based on phosphoric acid decomposition of Khodzhakul phosphorite powder**

Temperature, °C	Density (g/sm <sup>3</sup> ) at EPA:PP mass ratios					
	100:5	100:10	100:15	100:20	100:25	100:30
20	1.2106	1.250	1.3008	1.3445	1.3604	1.3765
30	1.2087	1.2479	1.2945	1.3406	1.3558	1.3707

40	1.206	1.2448	1.2893	1.3343	1.3502	1.365
50	1.2033	1.2417	1.2851	1.3279	1.3435	1.3593
60	1.2015	1.2386	1.28	1.3217	1.338	1.3537
70	1.1979	1.2346	1.2749	1.3155	1.3325	1.3481
80	1.1945	1.2307	1.2698	1.310	1.3271	1.3425

Table 4

**Viscosity of ammoniated phosphate pulps based on phosphoric acid decomposition of Khodzhakul phosphorite powder**

Temperature, °C	Viscosity (centipoise) at EPA:PP mass ratios					
	100:5	100:10	100:15	100:20	100:25	100:30
20	8.51	15.00	24.00	31.13	38.44	45.76
30	7.26	13.24	20.70	27.45	34.22	40.28
40	6.02	11.48	17.98	24.48	30.18	35.88
50	5.11	10.29	16.04	21.80	26.95	32.10
60	4.55	9.43	15.00	20.06	24.13	28.20
70	4.19	8.55	14.05	18.52	22.06	25.55
80	3.97	7.89	13.56	16.99	20.90	23.56

From the table. 3 it can be seen that with the ammonization of acid phosphate pulp and a temperature of 20°C with an increase in the mass fraction of phosphate raw materials from 5 to 30 g, the density of the ammonium phosphate pulp increases from 1.2106 to 1.3765 g/cm<sup>3</sup>, at 40 °C from 1.206 to 1.365 g/cm<sup>3</sup>, at 60 °C from 1.2015 to 1.3537 g/cm<sup>3</sup> and at 80°C from 1.1945 to 1.3425 g/cm<sup>3</sup>. The temperature of the process also has a tangible effect on the rheological properties of the ammonium phosphate pulp.

So, for the mass ratio of EPA:PP = 100:10 an increase in temperature from 20 to 80°C contributes to a decrease in the density of the ammonium phosphate pulp from 1.250 to 1.2307 g/cm<sup>3</sup>, for EPA:PP = 100:20 from 1.3445 to 1.310 g/cm<sup>3</sup> and for EPA:PP = 100:30 from 1.3765 to 1.3425 g/cm<sup>3</sup>. A similar pattern is observed for the viscosity of the ammonium phosphate pulp, that is, the more phosphate raw materials are introduced into the system, the higher the viscosity values, and the higher the temperature, on the contrary, the lower the viscosity of the ammonium phosphate pulp.

Thus, at a temperature of 20°C with an increase in the mass fraction of

phosphate raw materials from 5 to 30 g, the viscosity of the ammonium phosphate pulp increases from 8.51 to 45.76 centipoise, at 40°C from 6.02 to 35.88 centipoise, at 60°C from 4.55 to 28.19 centipoise and at 80°C from 3.97 to 23.56 centipoise. For EPA:PP = 100:10 an increase in temperature from 20 to 80°C leads to a decrease in pulp viscosity from 15.00 to 7.89 centipoise, for EPA:PP = 100:20 from 31.13 to 16.99 centipoise and for EPA:PP = 100:30 from 45.76 to 23.56 centipoise.

The highest density (1.3765 g/cm<sup>3</sup>) and viscosity (45.76 centipoise) values are found in the pulp obtained at an EPA:PP ratio of 100:30 and a temperature of 20°C. In any case, such pulp is easily pumped through pipelines to the BGS apparatus for granulation and drying.

Laboratory experiments have established that the most optimal mass ratios of EPA:PP appeared 100:20 and 100:25.

Under these conditions, the ammonium phosphate pulp at a temperature of 60°C has a density and viscosity of 1.32-1.34 g/cm<sup>3</sup> and 20.06-24.13 centipoise, respectively.

Thus, the yellow phosphorite powder of the Khodzhakul deposit is quite suitable for the production of ammonium phosphate fertilizer, where it can serve as a secondary phosphate raw material.

At the same time, the obtained acid phosphate and ammonium phosphate pulps can be pumped from one device to another in a liquid-flowing manner and without any difficulties.

### Conclusion.

1. In the range of 20-90°C, the density and viscosity of acid phosphate pulps obtained from the decomposition of phosphorite powder Khodzhakul with

phosphoric acid in a wide range of initial components (EPA:PP = 100:5-30). It is shown that the pulps have high fluidity (no more than 1.37 g/cm<sup>3</sup> and 7.08 centipoise).

2. The density and viscosity of phosphate pulps ammoniated to pH = 4.5 were measured. At optimal EPA:PP ratios = 100:20 and 100:25, ammophosphate pulp at 60°C has a density and viscosity of 1.32-1.34 g/cm<sup>3</sup> and 20.06-24.13 centipoise. It is easily transported by pumping devices without any restrictions and is granulated and dried in a BGS apparatus.

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# INVESTIGATION OF THE CHEMICAL-MINERALOGICAL COMPOSITION OF BENTONITE OF THE KHAUDAG DEPOSIT AND SYNTHESIS OF WINE FINING AGENTS BASED ON ITS

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**Abstract.** Fining is about removing unwanted material from wine while still in the cellar. It is part of the clarification and stabilisation process and involves adding a substance to the wine that will flush out certain elements that may cause a wine to look hazy or affect its aroma, colour or bitterness. Fining removes 'colloids', which are molecules that include tannins, phenolics and polysaccharides. The fining agent binds to the unwanted particles in the wine, which means they become sizeable enough to be filtered out. The chemical and mineralogical composition of the Khovdak bentonite clay for the production of sorbents was studied. Microscopic studies of samples of bentonite clays were carried out using an MBS-10 optical microscope in transmitted and polarized light with an installed digital camera with a magnification factor of up to 600 s. The study of the phase composition of samples of bentonite clays of the Khaudag deposit was carried out by X-ray analysis.

**Keywords:** bentonite clay, bentonite, sorption, phase composition, wastewater treatment, sorbent.

**Introduction.** Fining is understood as clarifying, making wine resistant, correcting its acidity, and accelerating the aging process. For this, wetting agents (gelatine, fish glue, egg protein, bentonite, etc.) are added to the wine, which react with the colloidal substances contained in the wine. Proteins and additives in wine react with astringents to form insoluble compounds. These compounds settle down in the sediments, and during the sedimentation, the small particles in the wine become

briquettes and make the wine clear [Abdullaev et al., 2012].

Fining is not only to clarify the wine, but also improves its taste and aroma, and increases its resistance to diseases. During wine fining, small particles of wine are adsorbed on the coagulated particles. As a result, under the influence of gravity, it forms bubbles, sinks down and separates from the wine [Abdullayev et al., 2019].

Bentonite, which is used as an adhesive, is considered an inert substance

and does not react chemically with substances contained in wine. It adsorbs small particles contained in the wine, forms coagulated patches, sinks down and separates from the wine [Ivanova et al., 2008].

In the world, bentonites and their varieties play a significant role in the form of a mineral supplement, in the breeding of farm animals and poultry, as well as deodorization of premises. The use of bentonite clays is associated with their chemical composition, which includes many vital micro and macro elements.

Various artificial and natural materials are used as sorbents: ash, coke breeze, peat, silica gels, aluminum gels, active clays, varieties of bentonite, etc. It should be noted that, depending on the nature and content of minerals, their sorption and selective properties of the oils removed from cottonseed related substances. Thus, for example, it is known from the literature that Angren kaolin effectively absorbs gossypol and its derivatives [Nadirov, 1973], and activated carbon absorbs carcinogenic substances (residues of a hydrocarbon solvent, 3,4-benzopyrene, etc.) [Ksenofontov , 2011].

In this study, compounds based on bentonite and organic monomers were synthesized [Eshkurbanov et al. 2022a-c]. Recommendations are given on the use of the synthesized compounds in the food industry.

It should be noted that in order to achieve maximum levels of water purification using sorbents based on bentonite clay, their activation and modification is required. In turn, the organization of the production of adsorbents on an industrial scale requires targeted research and the development of new and highly efficient technologies for the complex processing of bentonite clays based on their chemical and mineralogical composition, structure and sorption properties their further place of application.

In the Jarkurgan district of the Surkhandarya region, there is the Khaudag

deposit, where there are reserves of bentonite raw materials in the amount of 1091 thousand tons, which are developed by the MS-MARJON Chamber of Commerce and Industry to meet the needs of farms with their products as agro-ore raw materials and other areas of consumption.

Researchers [Eshkurbanov et al., 2022c] for the first time modified Khaudag bentonite with polymer compounds and obtained a new composition. Most natural clay adsorbents partially or completely do not adsorb the carcinogenic substance 3,4-benzo[a]pyrene from the extraction oil.

**Methods and materials.** This problem has been proven to be partially overcome with the help of the above synthesized compound. In addition, as a result of the research, the polymer product obtained on the basis of dimethylolurea and orthophosphoric acid (DMU+OPA) was reprocessed with bentonite and a composition was obtained. In order to determine the possible areas of application of this mechanical composite, its studied physical and chemical properties were presented in further studies [Eshkurbanov et al., 2022b].

A composition was created on the basis of Khaudag bentonite and a polymer additive, and practical work was carried out on its effectiveness in cleaning vegetable oils.[ Eshkurbanov et al., 2022a] Optimum conditions for obtaining an import-substitute composition for oil refining with the help of synthesized compositions were determined. According to it, it was found that the UFPA-1-B sorbent (based on urea-formaldehyde (UF) and phosphoric acid) has higher sorption properties than the UFAP-1-B (based on UF and ammonium phosphate) composition. In addition, it was determined that the optimal conditions for activation are 4 hours of activation using 15%  $H_2SO_4$  acid. It was found that the use of 2% in oil whitening with the help of the obtained compositions leads to maximum oil purification. The amount of bleaching sorbents used varies from 0.5 to 5%, depending on the amount of dyes in the oil

to be treated and the degree of bleaching required.

When an activated adsorbent is used in the bleaching process, a small amount of isomerization and the formation of glycerides containing sequentially linked fatty acids are observed. This, of course, leads to a decrease in the quality of refined oils and fats and a shortening of their shelf life. The conditions mentioned above and the size of the oil capacity require that the amount of activated earth used for bleaching be reduced as much as possible. At present, activated adsorbents are imported from foreign countries and used for adsorption purification of vegetable oils in various sectors of our oil industry [Mamajonova et al., 2020]. Localization of adsorbents coming from abroad and their use in the food industry remains one of the urgent issues of today.

In this research work, for the first time, studies were conducted on the use of Khaudag bentonite and its composite compound with polymer compounds for wine clarification in the wine industry. Before starting research work, bentonite of Khaudag is acid activated. After that, it is separately modified with polyacrylonitrile (PAN) and DMU.

A comprehensive study of the mineralogical composition of bentonite and its modified forms was carried out by the methods of X-ray, thermogravimetric and electron microscopic analyzes, the use of which makes it possible to explain the influence of changes occurring in the process of modification on their properties.

X-ray diffraction patterns were taken with an XRD-6100 X-ray powder diffractometer (Shimadzu, Japan). CuK $\alpha$  radiation was used ( $\beta$ -filter, Ni, 1.54178 current mode and tube voltage 30 mA, kV) and a constant detector rotation speed of 4 deg/min with a step of 0.02 deg, and the scanning angle varied from 4 to 80°.

The cell for DTA has a recorder of the temperature difference between the test sample and the standard - aluminum oxide Al<sub>2</sub>O<sub>3</sub> and a recorder of the sample temperature. The method of work includes preparing the device for operation, calibration processes, conducting the main test, processing curves, calculations and interpretation of the results obtained.

Electron microscopic studies were carried out on a scanning electron microscope (SEM) EVO MA10 SEM Cari Zeiss, the use of which makes it possible to view a sample on SEM, determine its quantitative elemental composition, and also obtain color microphotographs.

Thermogravimetric studies were performed using a Paulik-Paulik-Erdey derivatograph system. The heating rate of the samples was 10%/min, the mass of the test sample was 0.1 g.

The preparation of samples for X-ray phase analysis was carried out in accordance with the guidelines [Higerovich and Merkin, 1968 ; Gorshkov, 1981 ]. The objects under study were preliminarily dried to a constant mass, then ground in an agate mortar until they completely passed through a 006 sieve. unit cell parameters of clay samples according to the formulas below [Frank-Kamenetsky, 1984]:

$$a = \frac{b}{\sqrt{3}}$$
$$b = 6 * d_{060}$$
$$\sin\beta = \frac{2d_{020}}{a}$$
$$c = \frac{I * d_{001}}{\sin\beta}$$

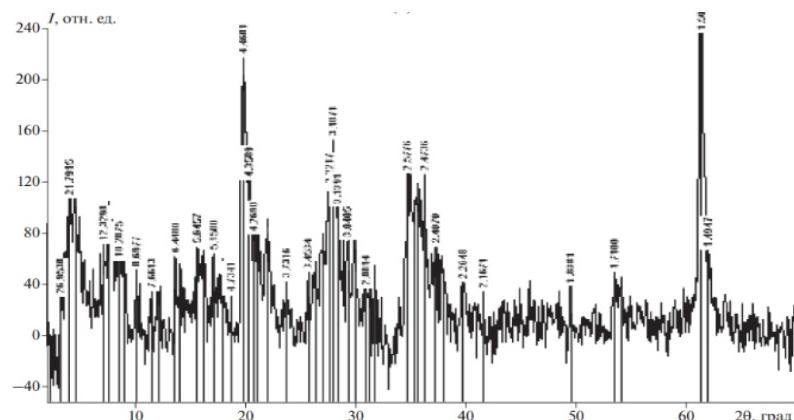
## Results and discussion.

Experiments have shown that a clay

sample from the Khaudag deposit contains mainly sodium montmorillonite (1.4250;

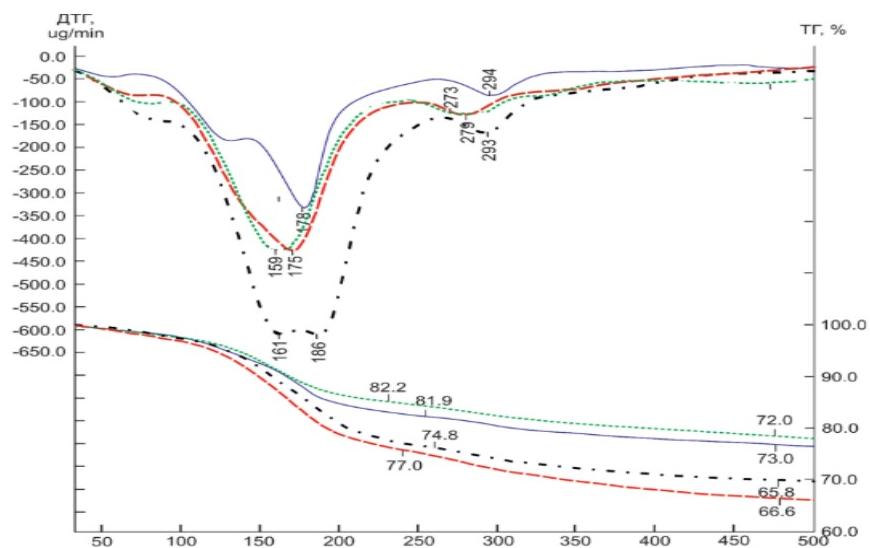
1.3012; 0.4263; 0.2729; 0.2298; 0.1801; 1.4090 nm). The presence of intense lines characteristic of montmorillonite (Fig. 1) proves that in this case it is the main rock-forming mineral. In addition to the lines characteristic of montmorillonite, there are also lines showing the presence of illite

(0.9891; 0.3870; 0.3853; 0.3611; 0.3001; 0.1597; 0.1699 nm), kaolinite (0.6993; 0.26001; 0.1499 nm), hydromicas (0.4606; 0.2971; 0.2487; 0.1677; 0.1561 nm), feldspar (0.3853; 0.2298; 0.1884). The sodium form of montmorillonite is proved by the reflex  $d_{001} = 1.301$  nm.



**Fig.1. X-ray diffraction pattern of a Khaudag bentonite sample**

Thermal analysis data are consistent with the results of the previous analysis. On the thermogram of Khaudag bentonite at temperatures of 80-125°C, an intense endothermic effect is observed, due to the release of adsorption and interlayer molecular water (Fig 2). The presence of an additional effect at temperatures with a maximum of about 535°C is caused by the removal of structural water. The third weakest endoeffect at temperatures above 790°C corresponds to the destruction of the anhydrous modification of montmorillonite and the transformation of the layered aluminosilicate matrix.



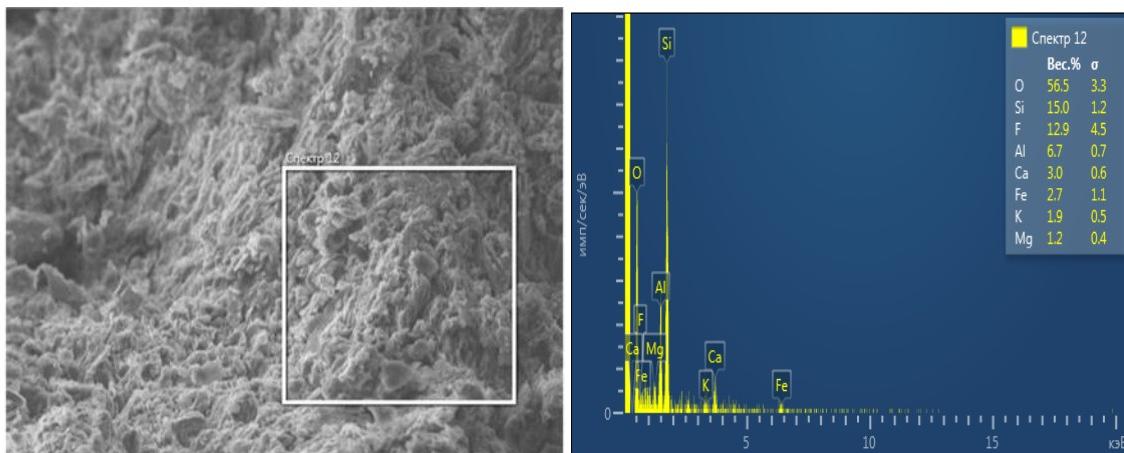
**Fig.2. Curve of thermal analysis of Khaudag bentonite sample**

Clay samples were studied by Fourier IR spectroscopy on a Nicolet iS50 Fisher Scientific spectrometer, as well as on a UV-NIR spectrophotometer (spectral region

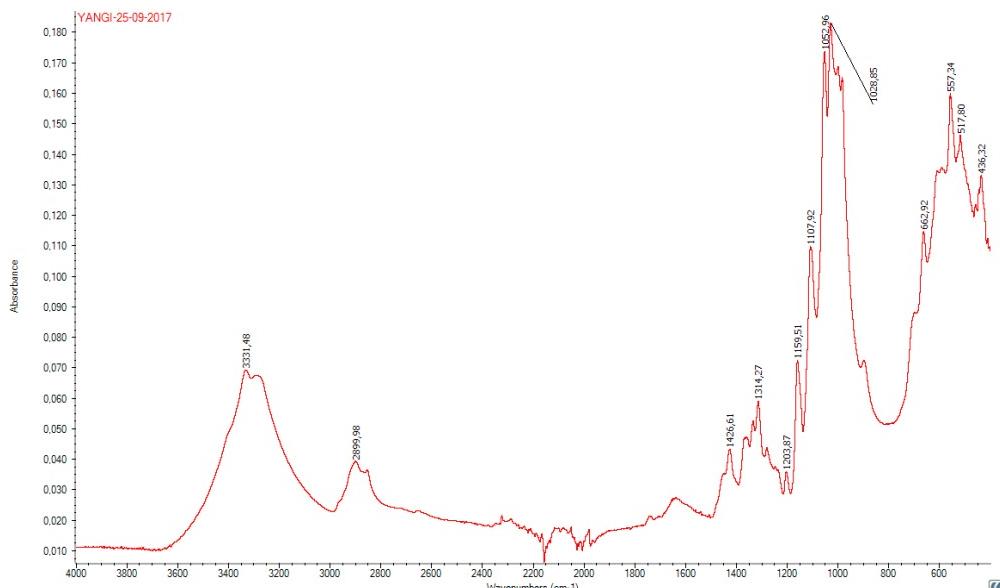
185-3300 nm) UV 3600 Shimadzu. For spectral tests, samples were prepared in powder form and in the form of tablets. The samples were pre-dried at 105°C in an

oven for more than 7 hours. The following chemical elements are fixed on the energy-dispersive spectrum of clay (in descending order): oxygen, silicon, aluminum, iron,

potassium, sodium, etc.(Fig 3) Microdiffractio analysis confirms the results obtained by the method of chemical analysis of the composition.



**Fig.3. Electron microscopic image of a sample of Khaudag bentonite**



**Fig.4. IR spectrum of Khaudag bentonite sample**

The interpretation of the above spectrum shows that the main bands shown on them belong to the valence bonds of silicon with oxygen and hydrogen with oxygen (Fig4). A well-defined broad band at  $1028.85\text{ cm}^{-1}$  corresponds to the stretching vibrations of the Si-O-Si tetrahedra of the silicon-oxygen framework, and the bands at  $517.80$  and  $436.32\text{ cm}^{-1}$  correspond to the bending vibrations of the Me-O bonds. The band in the interval  $662.92\text{ cm}^{-1}$  corresponds to the

Si-O-Si vibrations of rings of  $\text{SiO}_4$  tetrahedra. Intense bands in the interval  $2899.98$ - $3331.48$  and  $1426.61\text{ cm}^{-1}$  refer to OH-valence and deformation vibrations of free and bound water.

Chemical analysis of fine clay fractions was performed according to GOST 21216-2014 [GOST, 1995], according to which the weight percentages of  $\text{SiO}_2$ ,  $\text{TiO}_2$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{Fe}_2\text{O}_3$ ,  $\text{MgO}$ ,  $\text{MnO}$ ,  $\text{CaO}$ ,  $\text{Na}_2\text{O}$ ,  $\text{K}_2\text{O}$ , and  $\text{P}_2\text{O}_5$  were determined. It follows from the data of the

chemical analysis that the studied clay is rich in alkali metal ions. In tab. 1 also provides data on the chemical composition of Sherobod bentonite, as a control sample

and it shows changes in the chemical composition of bentonites from the Khaudag and Sherobod deposits before and after their enrichment.

Table 1

**Chemical composition of clay samples**

Name of chemical components	Khaudag bentonite, % before enrichment	Khaudag bentonite, % after enrichment	Sherobod bentonite, % before enrichment	Sherobod bentonite, % after enrichment
SiO <sub>2</sub>	61,2	55,3	54,91	38,02
Al <sub>2</sub> O <sub>3</sub>	16,3	21,2	14,6	30,5
CaO	3,6	3,8	1,6	1,8
Fe <sub>2</sub> O <sub>3</sub>	2,8	2,3	6,6	6,2
Na <sub>2</sub> O	2,4	2,2	1,9	1,7
MgO	3,6	3,8	1,6	1,8
MnO	0,7	0,8	0,4	0,8
K <sub>2</sub> O	2,6	2,3	1,65	1,4
P <sub>2</sub> O <sub>5</sub>	0,3	0,5	0,56	0,68
CO <sub>2</sub>	0,12	0,10	0,18	0,25
loss after ignition	6,38	7,7	16	16,85

From tab. Table 1 shows that the content of SiO<sub>2</sub> after enrichment of Khaudag bentonite by elutriation decreased from 61.2 to 55.3%, and of Sherobod bentonite - from 54.91 to 38.02%. And vice versa, the content of Al<sub>2</sub>O<sub>3</sub> after enrichment of Khaudag bentonite increased from 16.3 to 21.2%. At the same time, the content of coloring oxides (Fe<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub>, etc.) in both samples decreased by about 2 times. In terms of Al<sub>2</sub>O<sub>3</sub> and Fe<sub>2</sub>O<sub>3</sub> content, the enriched bentonite of the Sherobod deposit exceeds the enriched Khaudag bentonite. This favorably affects the quality of the resulting adsorbents and once again confirms the special need for the bentonite enrichment process before their activation.

Above, wine clarification processes were carried out with the help of acid-activated and modified adsorbents. During different periods of time, activated

adsorbents were used in the amount of 2% and clarification processes were carried out. The obtained results are presented in Table 2.

As can be seen from Table 2, the wine indicators clarified with the help of adsorbents obtained as a result of activation for 4 hours showed the best indicator. Therefore, 4 hours was taken as an optimal condition for further activation processes. For our next work, it is planned to carry on Khaudag bentonite, as this bentonite has been found to clean wine better than Pakistani alkaline bentonite.

The maximum amount of adsorbent used for acid concentration and clarification was used above. At the next stage, research was conducted to find the optimal conditions for acid concentration and adsorbent amount. The obtained results are presented in the following tables 3-4.

Table 2.

**Effect of activation time on wine clarification process**

Name of adsorbent	Activation time, hours	Wine color 35 yellow, in a cuvette 12.5 cm thick		Wine output, %
		Red Unit	Blue Unit	
Khaudag bentonite	Initially	14,2	0,3	-
	2	10,1	0,2	97,5
	4	7,6	0,1	97,2
	6	7,2	0,1	98,1
PAN + Khaudag bentonite	2	7,2	0,1	97,1
	4	6,8	0,09	97,6
	6	6,3	0,07	98,2
DMU + Khaudag bentonite	2	7,0	0,9	96,8
	4	6,4	0,07	97,5
	6	6,1	0,05	98,4
Pakistani Bentonite	2	8,2	0,3	96,8
	4	7,8	0,2	96,5
	6	7,6	0,2	97,2

Table 3

**Effect of acid concentration on wine clarification process**

Acid concentration, %	Wine color 35 yellow, in a cuvette 12.5 cm thick		Wine output, %
	Red Unit	Red Unit	
10	7,2	0,15	97,7
15	7,1	0,13	98,3
20	7,4	0,12	97,5
25	7,6	0,14	96,2

Table 4

**The influence of the amount of adsorbent on the wine clarification process**

Amount of adsorbent, mg	Wine color 35 yellow, in a cuvette 12.5 cm thick		Wine output, %
	Red Unit	Blue Unit	
1	7,6	0,12	96,9
1,5	7,3	0,14	97,5
2	7,8	0,15	96,3
2,5	8,2	0,14	96,7

From the tables 3 and 4 above, the most optimal condition for the activation of the adsorbent was determined to be the activation using 15%  $H_2SO_4$  acid for 4 hours. In addition, it was determined that the consumption of adsorbent for clarification is 1.5%.

**Conclusion.** In conclusion, the optimal conditions for obtaining an adsorbent that replaces import for wine clarification using local Khaudag bentonite

were determined. According to it, it was found that Khaudag bentonite has higher adsorption properties than Pakistani alkaline bentonite. Thus, a comprehensive study of the bentonite of the Khaudag deposit showed that its main constituent is the mineral montmorillonite. The clay of this deposit differs from other clays of Uzbekistan by a low content of harmful impurity non-clay materials.

In addition, it was determined that the optimal conditions for activation are 4 hours of activation using 15%  $H_2SO_4$  acid. It was determined that the use of 1.5% in wine clarification with the help of adsorbents leads to the maximum purification of wine.

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## MODELING THE PRODUCTION OF DIMETHYL ETHER FROM NATURAL GAS

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**Abstract.** The study utilizes the Katalco-58 industrial catalyst from Johnson Matthey Catalysts, composed of 13 wt.% Cu/27 wt.% ZnO/60 wt.% Al<sub>2</sub>O<sub>3</sub>, in the dehydration of methanol to DME. The catalytic activity of the samples was studied in an apparatus that allows the process to be investigated under steady-state conditions with a high-pressure flow reactor. The phase composition of the samples before and after catalytic tests was determined using a Shimadzu XRD-6000 diffractometer with unfiltered CuK $\alpha$  radiation ( $\lambda=1.5418 \text{ \AA}$ ). The porous structure and specific surface area of the samples were identified using the Tristar II (3020) Brunauer-Emmett-Teller method. The specific surface area was determined from nitrogen adsorption isotherms observed at -197°C. The pore volume was determined at a relative pressure of P/P<sub>0</sub>=0.99. The initial reaction mixture used was a combination of hydrogen and carbon monoxide supplied from cylinders and fed to the reactor. Samples were tested at pressures between 1-5 MPa and temperatures between 220-300°C, in steps of 20°C. Products were analyzed by chromatographic analysis on a "Crystal 5000.2" gas chromatograph. The water content was determined by the Karl Fischer method.

**Keywords:** synthesis gas, dimethyl ether(DME), methanol, catalyst, conversion.

**Introduction.** Using natural gas as an energy and chemical raw material offers the opportunity to reduce the consumption of conventional fuels and produce necessary products. Currently, in the industry, methane and its homologs are converted catalytically to produce hydrogen, synthesis gas, ammonia, methanol, liquid fuel, and other products [1]. The process of producing synthesis gas as a result of the conversion of light hydrocarbons is essential[2] as it offers the production of a variety of products based on simple CO and H<sub>2</sub> molecules [3].One of

the most developed processes in the industry is converting natural gas to methanol [4]. As not all plants can adapt to producing new products, it is promising to produce new materials based on existing technologies. For example, the production of dimethyl ether (DME), an alternative to diesel fuel, can be promoted based on existing methanol production [5]. The study of the effect of external pressure showed that the yield of DME is a parabolic relationship, the maximum of which corresponds to 2 MPa. CO conversion increases with increasing pressure[6]. The

main industrial process for producing dimethyl ether is the catalytic dehydration of methanol, conducted at high pressures and temperatures of 270-310°C. However, achieving high selectivity in this temperature range is challenging, as carbonaceous deposits can form. Therefore, an additional purification step is necessary to ensure the purity of DME. The obtained synthesis gas has a noticeable effect on the production quality of both methanol and dimethyl ether, making it crucial to efficiently design the synthesis gas production stage. For economic efficiency, carbonate anhydride is used in the methane bubble conversion reactor. In this way, the bubbly conversion of methane is implemented, which not only addresses the issue of using carbonate anhydride but also significantly increases the carbon oxide concentration in the synthesis gas and decreases the hydrogen concentration[7].

For this process, there are two classes of catalysts: low-temperature sulfocation types such as Amberlist-15, Dowex-50, Ky-1, Ky-2, and oxide catalysts (aluminum, zirconium oxides). The disadvantages of the sulfocation catalysts are their low thermal stability (operating temperature range 80-150°C). The shortcomings of oxide catalysts, for instance,  $\gamma$ -Al<sub>2</sub>O<sub>3</sub>, include their low catalytic activity at temperatures below 200°C. This leads to the possible formation of side products and the necessity of additional expenses for heating the reactor. To overcome the above disadvantages, the 13 wt.% Cu/27 wt.% ZnO/60 wt.% Al<sub>2</sub>O<sub>3</sub> polyoxide catalyst is suggested, which allows the hydration reaction of methanol at a temperature range of 120-220°C. Based on literature data, a step-by-step mechanism for the dehydration reaction of methanol in  $\gamma$ -Al<sub>2</sub>O<sub>3</sub> catalyst has been adopted.

Currently, the day by day decrease of oil reserves puts the task of searching for an alternative source of energy to replace oil before the scientists of the world. Such alternative sources are natural gas and

biomass. To date, scientists of the world are interested in obtaining ethylene in one step by oxycondensation of methane, taking methanol and diethers from methane through synthesis gas and synthesizing lower molecular alkenes based on them, and at the same time using petroleum satellite gases effectively, that is, obtaining lower molecular unsaturated hydrocarbons based on them [8-22]. Synthesis of the above-mentioned processes and substances that act as semi-products in petrochemical and organic synthesis is one of the urgent issues for today.

**Experimental part.** In this study, the industrial catalyst Katalco-58 from Johnson Matthey Catalysts, with a composition of 13 wt.% CuO/27 wt.% ZnO/60 wt.% Al<sub>2</sub>O<sub>3</sub>, was used for the dehydration of methanol to DME. For the simplified step-by-step mechanism of this dehydration reaction, an appropriate kinetic model was derived using the Horii method. During the model derivation, the adsorption-desorption stages were assumed to be fast. Methanol was chosen as the main reactant; hence, the formation rates of water and dimethyl ether (DME) were calculated based on constant ratios. To study the activity of the selected catalysts in the methanol dehydration reaction, laboratory flow-catalytic devices with catalyst volumes of 2 mL, 10 mL, 22 mL, and 100 mL were constructed and assembled. Synthetic gas-derived methanol was used as feedstock. The composition of the synthesis gas(CO,H<sub>2</sub>) was analyzed using both gas chromatography and a portable gas analyzer. The amounts of oxygen, nitrogen, carbon monoxide (CO), carbon dioxide(CO<sub>2</sub>), and hydrogen in the synthesis gas were determined. In all experiments, the results of gas analysis in the gas analyzer and gas chromatography matched well. Methods for gas chromatographic analysis of synthesis gas conversion to methanol and methanol hydration products were developed. Separators for clearly distinguishing

oxygen and hydrocarbons in the gas chromatograph were selected. High precision in analyzing methanol, dimethyl ether, and water at any concentration in the reaction products was noted.

The study of the catalysts' activity was carried out in a device allowing the process to be studied under continuous conditions with a high-pressure flow reactor. The initial reaction mixture consisted of hydrogen and carbon monoxide fed from cylinders and mixed before entering the reactor. The samples were tested under pressures of 1-5 MPa and temperature ranges of 220-300°C with a 20°C increment. The products were analyzed on a "Crystal 5000.2" gas chromatograph. The amount of water was determined according to the Karl Fischer method. The phase composition of the investigated samples was determined before and after catalytic tests using the Shimadzu XRD-6000 diffractometer with unfiltered CuK $\alpha$  radiation ( $\lambda=1.5418 \text{ \AA}$ ) through X-ray phase analysis. Phase composition analysis was performed using the PCPDFWIN database and the multi-network programs POWDER CELL 2.4 and PDF 4+. The porous structure and specific surface area of the samples were identified using the Tristar II (3020) Brunauer-Emmett-Teller (BET) method. The specific surface area was determined from nitrogen adsorption isotherms observed at -197°C. The pore volume was determined at a relative pressure of P/P0=0.99. The surface morphology of the samples was studied using a high-resolution digital DFC280 R2 camera equipped with a Leica optical polarization microscope and an electron microscope VEGA II LMU based on the energy-dispersive microanalysis system INCA ENERGY 350. This was done to study the structure and composition of natural objects using scanning electron microscopy and X-ray spectral analysis. The primary electron beam energy was 20 kV. Differential thermal analysis (DTA) of the samples was carried out on a combined TGA-DSC analyzer Q-600 (TA Instruments, USA). The heating rate in the

air atmosphere was 10 °C /min, and the standard was Al<sub>2</sub>O<sub>3</sub>. Temperature Programmed Desorption (TPD) analysis was performed on the Chemisorb 2750 chemisorption analyzer. The sample was desorbed in a flow of a 10 vol.% H<sub>2</sub>+Ar mixture, heating at a linear rate of 10°C/min up to 600°C. CO TPD investigation was conducted in the Chemisorb 2750 chemisorption analyzer. To determine the acidic properties of the samples, an FTIP-8300 IR-spectrometer was used. The initial vacuumed sample's IR spectra were recorded after introducing CO, at liquid nitrogen temperature, in the 400-6000 cm<sup>-1</sup> range with 4 cm<sup>-1</sup> resolution and collecting 100-400 scanner descriptions.

The interaction character between reagents and the surface of catalysts was studied using the temperature programmed desorption method in a thermosorption device combined with mass spectrometric analysis (TPD-MS). The heating rate was set at 9°C/min, and the gas flow rate was 19 mL/min. Before the experiment, the sample was heated in a helium flow at a rate of 20°C/min up to the desorption temperature and then kept at this temperature for 1 hour. Adsorption was carried out at 100°C for 30 minutes. The composition of the products of thermal desorption from the catalyst surface was studied in the QMS 300 quadrupole mass spectrometer, which can detect gas mixture components at pressures from 10 mbar to 1 bar and concentrations as low as 1 ppm.

**Experimental results and their discussion.** In the industrial synthesis of methanol(CH<sub>3</sub>OH), DME is produced as an intermediate product on a copper-zinc-aluminum catalyst. Two classes of catalysts were selected for the methanol dehydration reaction - acid catalysts with a polymer medium of moderate heat resistance and acid polyoxide catalysts made of oxides from groups III, IV, V of Dmitri Mendeleev's periodic table.

**Modeling the kinetics of dimethyl ether synthesis from methanol:** In the 13

wt.% CuO/27 wt.% ZnO/60 wt.% Al<sub>2</sub>O<sub>3</sub> catalyst, the step-by-step mechanism of methanol dehydration reaction is. For this simplified step-by-step mechanism of methanol dehydration, the kinetic model corresponding to it can be obtained using the Horuti method. In obtaining the model, the adsorption-desorption steps were assumed to be fast. Methanol was chosen as the primary substance, hence the formation rates of water and dimethyl ether (DME) were calculated based on constant ratios. The chemicals involved in the

methanol dehydration reaction can be divided into two categories. The first category includes stable non-Bodenstein substances: methanol, dimethyl ether, and water. The second includes unstable Bodenstein substances: adsorbed methanol, dimethyl ether, water, and free active centers. We can formulate the main system of kinetic equations by distinguishing between Bodenstein and non-Bodenstein types. Rates of change in concentrations of non-Bodenstein (stable) substances:

$$R_{CH_3OH}^B = -W_1 \quad (1)$$

$$R_{CH_3OCH_3}^B = W_3 \quad (2)$$

$$R_{H_2O}^B = W_4 \quad (3)$$

Rates of change in concentrations of Bodenstein (unstable) substances:

$$R_\theta^B = -W_1 + W_3 + W_4 \quad (4)$$

$$R_{CH_3OH\theta}^B = W_1 - 2W_2 \quad (5)$$

$$R_{CH_3OCH_3\theta}^B = W_2 - W_3 \quad (6)$$

$$R_{H_2O\theta}^B = W_2 - W_4 \quad (7)$$

Using Bodenstein's quasi-stationary approach, we get:

$$R_\theta^B + R_{CH_3OH\theta}^B + R_{CH_3OCH_3\theta}^B + R_{H_2O\theta}^B = 0 \quad (8)$$

$$X_\theta + X_{CH_3OH\theta} + X_{CH_3OCH_3\theta} + X_{H_2O\theta} = 1 \quad (9)$$

Expressing the rates of fast steps through the rates of slow steps (limiting rate):

From  $R_{CH_3OH\theta}^B = W_1 - 2W_2$ , we get  $W_1 = 2W_2$

From  $R_{CH_3OCH_3\theta}^B = W_2 - W_3$ , we get  $W_2 = W_3$

From  $R_{H_2O}^B = W_2 - W_4$ , we get  $W_2 = W_4$

From the above, we deduce the kinetic model as:

$$R_{CH_3OH\theta}^B = -2W_2 \quad (10)$$

$$R_{CH_3OCH_3\theta}^B = W_2 \quad (11)$$

$$R_{H_2O}^B = W_2 \quad (12)$$

Since the total matrix of reaction rates is of degree 1 in direction, we can have one primary component. We can choose methanol as the primary component and dimethyl ether and water as secondary components. Their concentrations can be expressed through invariant ratios:

$$R_{CH_3OCH_3}^B = R_{H_2O}^B = -\frac{R_{CH_3OH}^B}{2} \quad (13)$$

To calculate the rate of change of benzene, methanol, water, and dimethyl ether, it is necessary to use the equations (10)-(12).

$$R_{CH_3OH}^B = -2W_2 = -2(W_{+2} - W_{-2}) = 2(k_{+2}X_{CH_3OH\theta}^2 - k_{-2}X_{CH_3OCH_3\theta}X_{H_2O\theta}) \quad (14)$$

The concentration of unstable (intermediate) substances is expressed through the concentration of stable substances:

$$X_{CH_3OH\theta} = K_{(1)}X_{CH_3OH}X_\theta \quad (15)$$

$$X_{CH_3OCH_3\theta} = (K_{(3)})^{-1}X_{CH_3OCH_3}X_\theta \quad (16)$$

$$X_{H_2O\theta} = (K_{(4)})^{-1}X_{H_2O}X_\theta \quad (17)$$

Substituting the equations (15)-(17) into the invariant relationship  $X_\Theta + X_{CH_3OH\Theta} + X_{CH_3OCH_3\Theta} + X_{H_2O\Theta} = 1$  we obtain:

$$X_\Theta = \frac{1}{1+K_{(1)}X_{CH_3OH}+(K_{(3)})^{-1}X_{CH_3OCH_3}+(K_{(4)})^{-1}X_{H_2O}} \quad (18)$$

$$X_{CH_3OH\Theta} = \frac{K_{(1)}X_{CH_3OH}}{1+K_{(1)}X_{CH_3OH}+(K_{(3)})^{-1}X_{CH_3OCH_3}+(K_{(4)})^{-1}X_{H_2O}} \quad (19)$$

$$X_{CH_3OCH_3\Theta} = \frac{(K_{(3)})^{-1}X_{CH_3OCH_3}}{1+K_{(1)}X_{CH_3OH}+(K_{(3)})^{-1}X_{CH_3OCH_3}+(K_{(4)})^{-1}X_{H_2O}} \quad (20)$$

$$X_{H_2O\Theta} = \frac{(K_{(4)})^{-1}X_{H_2O}}{1+K_{(1)}X_{CH_3OH}+(K_{(3)})^{-1}X_{CH_3OCH_3}+(K_{(4)})^{-1}X_{H_2O}} \quad (21)$$

$$R_{CH_3OH}^B = \frac{-2k_{+2}(K_{(1)})^2X_{CH_3OH}^2+2k_{-2}(K_{(3)})^{-1}(K_{(4)})^{-1}X_{CH_3OH}X_{H_2O}}{(1+K_{(1)}X_{CH_3OH}+(K_{(3)})^{-1}X_{CH_3OCH_3}+(K_{(4)})^{-1}X_{H_2O})^2} \quad (22)$$

The rate of change of methanol concentration is expressed through the concentration of stable substances, while the rate of change in the concentrations of water and dimethyl ether is calculated based on invariant ratios.

In conclusion, the kinetic model of the synthesis reaction of dimethyl ether(DME) can be represented as:

$$R_{CH_3OH}^B = \frac{-2k_{+2}(K_{(1)})^2\left(K_{CH_3OH}^2 + \frac{P_{CH_3OCH_3}P_{H_2O}}{K_p}\right)}{(1+K_{(1)}X_{CH_3OH}+(K_{(3)})^{-1}X_{CH_3OCH_3}+(K_{(4)})^{-1}X_{H_2O})^2} \quad (23)$$

where  $K_p = \frac{P_{CH_3OCH_3}P_{H_2O}}{P_{CH_3OH}^2}$  -is the equilibrium constant of the dimethyl ether synthesis reaction,

$$K_{complex1} = 2k_{+2}(K_{(1)})^2, \\ K_p = K_{complex2} = 2k_{+2}(K_{(1)})^2/k_{-2}(K_{(3)})^{-1}(K_{(4)})^{-1}$$

are the cumulative kinetic constants (equilibrium constant of the DME synthesis reaction), and P - is the pressure in the reactor.

**Evaluation of the kinetic experiments results and model constants of the methanol dehydration reaction:** The experiments were carried out in various concentrations of methanol in raw materials, at a liquid flow rate of 0.5-12 hours<sup>-1</sup>, and in a reaction zone temperature ranging from 90°C to 180°C. Generally, both types of catalysts showed similar activity at the same reaction temperature; additionally, above 160°C, the polymerizing catalyst rapidly lost its activity. The results of the first series of experiments in the laboratory apparatus are presented in Table 1. The data in Table 1 indicate that the first, second, and fourth stages of the process can be quickly calculated, and the methanol-dimethyl ether system is almost balanced.

According to the experimental results, the parameters of the kinetic model were estimated using the linear least squares method.

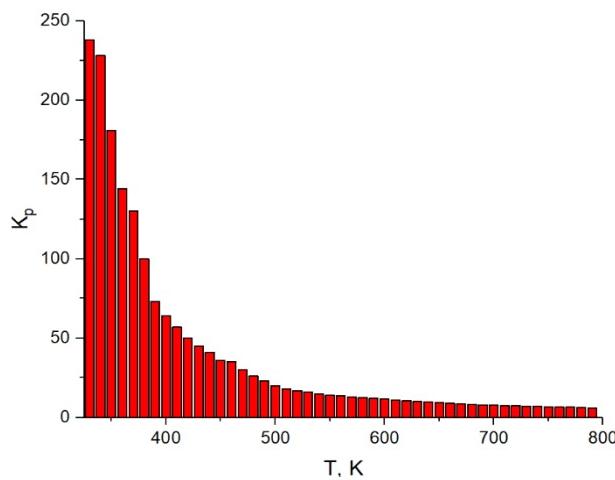
The model's differential equations were solved using the fourth-order semi-implicit Runge-Kutta method. This method requires calculating the right side of the equation four times at each step. The general error of this method is of order O(h<sup>4</sup>).

The suitability of the model to the experiment was maximized using the Newton method and random sample search. The model predictions match the experimental data very well, with a discrepancy not exceeding 5%.

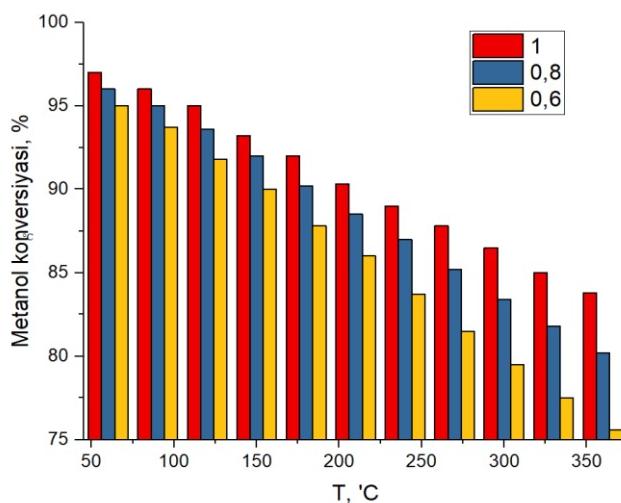
table 1

**Results of the first series of kinetic experiments on the activity study of the 13 wt.% CuO/27 wt.% ZnO/60 wt.% Al<sub>2</sub>O<sub>3</sub> catalyst**

Experiment t№	Methanol Molar Flow Rates, mol/hour	T, K	P, MPa	Methanol Conversion, %	
				Experimental	Calculated
1.	2.46	413	0.10	15.1	14.90
2.	2.46	423	0.10	32.2	31.22
3.	2.46	433	0.10	51.9	52.79
4.	2.46	443	0.10	73.5	73.78
5.	2.46	453	0.10	86.0	85.77
6.	4.18	463	0.17	90.5	90.26
7.	4.18	423	0.17	43.9	43.89
8.	4.18	433	0.17	64.5	64.36
9.	4.18	443	0.17	81.8	81.78
10.	4.18	453	0.17	89.4	89.57



**Figure 1. Dependence of the methanol synthesis reaction equilibrium constant on the reaction temperature**



**Figure 2. Dependence of the degree of methanol conversion on temperature at 1 atm pressure and initial mixtures with molar fractions of methanol being 0.6 (▲), 0.8 (■), 1.0 (□)**

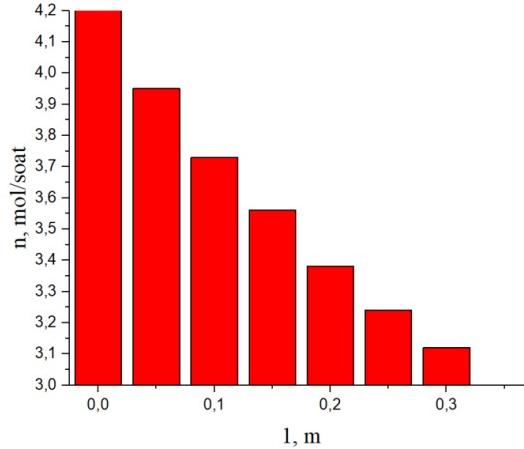
**Modeling methanol dehydration reactions in a laboratory reactor.** Results of modeling the dehydration reactions of methanol in a tubular flow reactor with an inner tube diameter of 2 cm, a reaction zone length of 31.8 cm, and a loaded catalyst volume  $V_{cat}= 0.1$  L are presented in FIGUREEures 3-6.

For the synthesis of DME from methanol, it is also necessary to study in detail the effect of water on the work of the

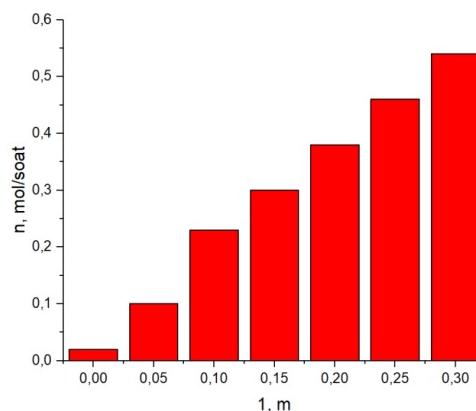
catalyst, as water poisons all inorganic acid catalysts. However, sulfo-cationite catalysts, unlike poisoning by water, are regenerable. When water is desorbed from an inorganic catalyst (polyoxide compositions), it maintains its activity, which is an advantage over sulfo-cationite samples.

Between temperatures of 413-423 K, a low conversion rate of methanol was observed:

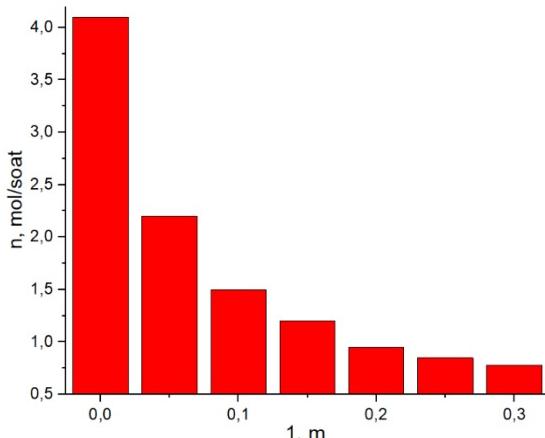
T=413 K, P=0,1 MPa,  $n^o_M=4.18$  mol/hour  
 Methanol conversion rate – 9.35%  
 T=413 K, P=0,17 MPa,  $n^o_M=4.18$  mol/hour  
 Methanol conversion rate– 21.39%  
 T=423 K, P=0,17 MPa,  $n^o_M=4.18$  mol/hour  
 Methanol conversion rate– 42.96%



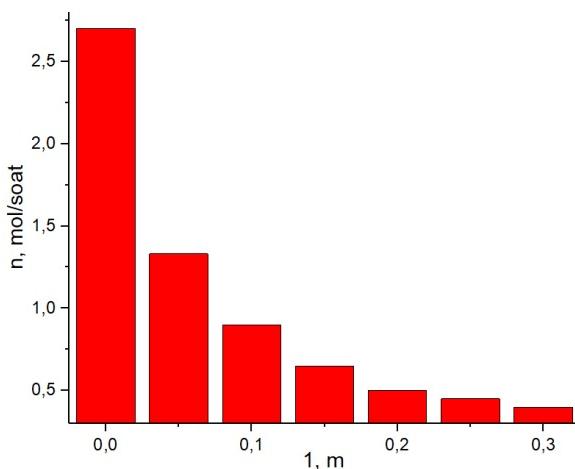
**Figure 3. Change in methanol molar flow along the reactor length: T=423 K, P=0,2 MPa,  $n^o_M=4.18$  mol/hour**



**Figure 4. Change in DME molar flow along the reactor length: T=413 K, P=0,2 MPa,  $n^o_M=4.18$  mol/hour. Methanol conversion 26.88%**



**Figure 5. Variation of methanol molar flow along the reactor length: T=443 K, P=0.2 MPa, n<sup>o</sup><sub>M</sub>=4.18 mol/hour, n<sup>o</sup><sub>DME</sub>=0.2 mol/hour, n<sub>water</sub>=0.2 mol/hour**



**Figure 6. Variation of methanol molar flow along the reactor length: T=413 K, P=1.0 MPa, n<sup>o</sup><sub>M</sub>=2.75 mol/hour. Methanol conversion 93.3 %**

Long-term stability tests of the 13 wt.% CuO/27 wt.% ZnO/60 wt.% Al<sub>2</sub>O<sub>3</sub> catalyst were conducted over 1000 hours of operation. Moreover, it was found that the catalyst almost did not lose its activity under the conditions of P=0.2 MPa and T = 181. In a 13 wt.% Cu/27 wt.% ZnO/60 wt.% Al<sub>2</sub>O<sub>3</sub>, methanol can be efficiently converted to dimethyl ether (DME) at a volumetric rate of 0.8 h<sup>-1</sup>. At the end of the research phase dedicated to studying the chemical transformation process, we turn to the analysis of the catalyst particle and its behavior in the catalytic reactor. A quasi-homogeneous model was used as a particle model. Macrokinetic parameters of the model were calculated using known correlation equations and were further

refined with experimental data. Efficiency factors for the catalyst granules were calculated accordingly. Apparently, the efficiency factor values for all substances are approximately 0.6.

The catalyst (a new high-silica zeolite catalyst 13 wt.% CuO/27 wt.% ZnO/60 wt.% Al<sub>2</sub>O<sub>3</sub>) is distinguished by its crystalline, porous structure. The new catalyst allows processing a wide range of raw hydrocarbons. As a result, high-octane additives (with an octane number of 90-91) can be obtained from gas condensate, and the propane(C<sub>3</sub>)-butane(C<sub>4</sub>) fraction is reprocessed into alkyl aromatic hydrocarbons.

During the experiment, catalyst tablets of sizes 3x3 mm and 6x4 mm of 13

wt.% CuO/27 wt.% ZnO/60 wt.% Al<sub>2</sub>O<sub>3</sub> were used. Ignoring the impact of diffusion on similar-sized tablets for the catalytic process is not feasible. Therefore, the

process was analyzed at the level of the catalyst particle. The particle model is as follows:

$$\begin{aligned} \frac{1}{R^2} \cdot \frac{d}{dR} \cdot \left( R^2 D_1(R) \frac{dc}{dR} \right) &= K_S S(c - c_i) \frac{1}{r^2} \cdot \frac{d}{dr} \cdot \left( r^2 D_2(r) \frac{dc}{dr} \right) = R_i^B(c_i, r) \quad \frac{1}{R^2} \cdot \frac{d}{dR} \\ \left( R^2 \lambda_1(R) \frac{dc}{dR} \right) &= \alpha_S S(T - T_i) \quad \frac{1}{r^2} \cdot \frac{d}{dr} \cdot \left( r^2 \lambda_2(r) \frac{dc}{dr} \right) = \sum_{u=1}^p \Delta H_u r^H(T_i, \vec{c}_i) \end{aligned} \quad (24)$$

Boundary conditions:

$$R=0 \quad \frac{dc}{dR} = 0 \quad \frac{dT}{dR} = 0 \quad R=R_3 \quad c(R_3)=c_{surf} \quad K_S S(c - c_i) = D \frac{dc}{dr} \Big|_{r=r_{kp}}$$

Specific efficiency factor values for different reactants are: Methanol – 1.02, Dimethyl ether – 1.01, Ethylene – 0.99, Propylene – 0.98, Butylene – 0.97, Cyclohexane – 0.95, Methylcyclohexane – 0.91, Benzene – 0.93, Toluene, xylenes – 0.87, Trimethylbenzenes – 0.87, Tetramethylbenzenes – 0.86.

Based on the conducted kinetic studies and the analysis of the catalyst particle's performance, it was determined: For methanol dehydration reaction, a zeolite catalyst with the following characteristics is required

Si/Al ratio 75-200, Zeolite particle diameter 1 μ, Zeolite-binder ratio – 0.6, Catalyst particle size, Diameter – 4 mm

Height – 2 mm.

#### DME synthesis catalytic reactor

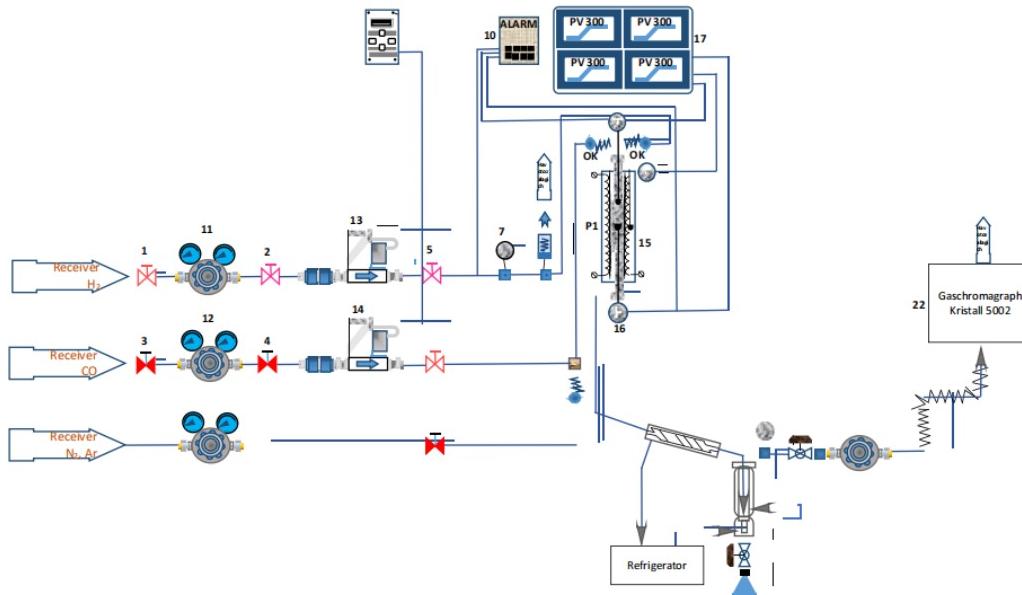
**model:** The device's scheme and description. The operation of catalytic drying is as follows figure 7 model of demethyl ether extraction device from synthesis gas. The system is cleansed with nitrogen, and operating pressure is generated by employing valves (1)-(6). The pressure is controlled by manometers (7)-(8) using "up to" (9) pressure regulator. Work safety is provided by an alarm device (10). Carbon (II) oxide and hydrogen are delivered to the reactor via two independent pipelines, pressure regulators from cylinders and dust filters in gas flow regulators. Hydrogen and carbon (II) oxide are then delivered into the catalytic reactor (15) through barrier-capable and reverse valves, where they are combined at the

$$T(R_3)=T_{surf} \quad R=0 \quad \frac{dc}{dr} = 0 \quad \frac{dT}{dr} = 0 \quad (25)$$

$$r=r_{kp} \quad \alpha_S S(T - T_i) = \lambda \frac{\partial T}{\partial r} \Big|_{r=r_{kp}}$$

reactor entry and heated to the required temperature. The reactor block is made up of a reactor, an electric furnace, and a reverse valve system. The reactor is comprised of a stainless steel pipe with a 12 mm internal diameter. A one-zone electric furnace heats the reactor, allowing the temperature above the catalyst layer to be maintained with a 5°C error. The reactor block is linked to a TXA controller chromalumel thermopara (0-1200°C) thermometer (17), which is placed in the catalyst layer (16) and controls the four-channel temperature as specified. A glass fiber catalyst passage grating is positioned at the bottom of the reactor, where the catalyst is located. The catalyst layer is 4.4 cm tall, and the temperature ranges from 200 to 300 °C. The temperature of the oven and the Steamer are both adjusted simultaneously. In order to remove the water, methanol and hydrocarbons (dimethyl ether, CO, H<sub>2</sub>, CO<sub>2</sub>, CH<sub>4</sub>, methanol vapor) formed after the reaction in the reactor, the gas mixture of the products is removed from the system with a one-time cooler (18) and circulating water at room temperature. passes through the separation device in the high-pressure separator (19) and, after separating the products in the high-pressure separator, is lowered into the condensate receiver (21) through the condensate adjustment valve (20). Gas products leave the high-pressure separator through the side nozzle, screw, back return pressure reducer (9) with the

help of a suction fan, through the analytical control system (22).



**Figure 7. Model of demethyl ether extraction device from synthesis gas**

$$\begin{aligned}
 u \frac{\partial \vec{c}}{\partial l} + D \left[ \frac{\partial^2 c}{\partial r^2} + \frac{1}{r} \frac{\partial c}{\partial r} \right] \pm [K] S_H (\vec{c} - \vec{c}_{surf}) &= 0 \\
 u c_p \rho \frac{\partial \vec{T}}{\partial l} + \lambda \left[ \frac{\partial^2 T}{\partial r^2} + \frac{1}{r} \frac{\partial T}{\partial r} \right] \pm [\alpha] S_H (T - T_{surf}) &= 0 \\
 [\eta] R^b (\vec{c}_{surf}, T_{surf}) = [K] S_H (\vec{c} - \vec{c}_{surf}) \\
 \sum_{u=1}^p \Delta H_u \vec{\eta}_u r_u (\vec{c}_{surf}, T_{surf}) &= [\alpha] S_H (T - T_{surf})
 \end{aligned} \tag{25}$$

Boundary conditions:

$$\begin{aligned}
 l=0 \quad \vec{c}(0, r) &= \vec{c}_{inlet}(r) \quad T(0, r) = T_{inlet}(r) \\
 r=0 \quad \frac{\partial \vec{c}}{\partial r} &= 0 \quad \frac{\partial T}{\partial r} = 0 \\
 r=R \frac{\partial \vec{c}}{\partial r} &= 0 \lambda \cdot \frac{\partial T}{\partial r} \Big|_{r=r_{kp}} = (T - T_{ambient})
 \end{aligned}$$

where:  $\lambda$  – thermal conductivity of the stream;  $D$  – diffusion (backflow) coefficient of the flow;  $[K]$  – mass transfer coefficients for reactors;  $[\alpha]$  – mass transfer coefficient from the particle to the flow;  $C_p$  – heat capacity of the mixture;  $\rho$  – density of the mixture;  $[\eta]$  – efficiency factor matrix for reactants;  $[\vec{\eta}]$  – direction-specific final reaction efficiency factor matrix;  $\Delta H_u$  – heat effect of the  $u$ -reaction;  $S$  – gas-solid phase separation interface;  $\vec{c}$  – reactant concentration in the gaseous phase;  $\vec{c}_{surf}$  – reactant concentration on the catalyst surface.

**Conclusion.** The selectivity and yield of methanol conversion products are notably evident in catalysts composed of 13 wt.% CuO/27 wt.% ZnO/60 wt.% Al<sub>2</sub>O<sub>3</sub>.

From the results of testing various model samples, we selected the composition of the catalysts and the conditions of the process, achieving both high efficiency and integral selectivity for the targeted products.

When methanol undergoes the conversion process with carbon monoxide without the presence of an inert gas, the reactor's productivity remains largely unchanged.

It's possible to separate the products from the altered gas by cooling the converted gas and condensing them. The mixture of methyl formate, formaldehyde, and dimethyl ether derived from methanol can be isolated from water using

distillation, given the significant differences in the boiling points of these components.

A rise in temperature results in a marginal decrease in methanol conversion. This observation aligns with experimental data, indicating that methanol conversion trends towards an equilibrium state.

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UDC 661.152.5

## STUDY OF INTERACTION OF COMPONENTS IN ZnSO<sub>4</sub> – NH<sub>4</sub>H<sub>2</sub>PO<sub>4</sub> – H<sub>2</sub>O SYSTEM

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### Abstract:

**Objective.** To theoretically substantiate the interaction of zinc sulfate with monoammonium phosphate, an isomolar series was used, based on the ratio of the components ZnSO<sub>4</sub> and NH<sub>4</sub>H<sub>2</sub>PO<sub>4</sub>.

**Methods.** The physicochemical properties of diluted solutions were studied by the isomolar series method to justify the interaction between zinc sulfate and monoammonium phosphate. Based on the ratio of components in the ZnSO<sub>4</sub> and NH<sub>4</sub>H<sub>2</sub>PO<sub>4</sub> system, pH value, density, refractive index, viscosity and crystallization temperature of the mixture of 0,01 M solutions were measured.

**Results.** According to the results of the physicochemical characteristics of diluted solutions in the  $[ZnSO_4(0.01M)]:[NH_4H_2PO_4(0.01M)]$  system, i.e., the pH environment, density, viscosity, refractive index and crystallization temperature values, one deviation corresponding to the presence networks of the initial components is observed. Based on the results of the diagram, it is expressed in the ratio  $[ZnSO_4(0.01M)]:[NH_4H_2PO_4(0.01M)]=4:6$ .

**Conclusion.** From the obtained results, it can be concluded that changes in the physicochemical properties of solutions occur even at the above amount of zinc sulfate and monoammonium phosphate with the composition ratio  $[ZnSO_4(0.01M)]:[NH_4H_2PO_4(0.01M)]=4:6$ . This shows that regardless of the initial concentration of zinc sulfate, when a small amount of monoammonium phosphate is added, a change in the composition of the solution occurs.

**Keywords:** zinc sulfate, monoammonium phosphate, Ostromyslensky-Job isomolar series method, pH value, density, viscosity, refractive index, crystallization temperature.

**Introduction.** In connection with the rapid growth of the population and the reduction of cultivated areas to a certain extent, there is an increasing need to develop and scientifically justify measures to increase soil fertility, and the quality and weight of the harvest from agricultural crops [1]. Measures to improve the nutritional quality of plants by growing crops, and providing them with nutrients necessary for human health are of great interest [2]. Nutrient availability is a key factor in plant growth and development [3]. In recent years, improper use of soil resources, including intensive cultivation without proper replenishment of nutrients, restriction of crop rotation, and low addition of organic matter, has led to a decrease in crop yield and quality, as well as micronutrient deficiencies [4-6] in soil, crops, animals, and humans [7]. When plants are grown in microelement-deficient soils, agricultural products with a low content of microelements are produced, which leads to hidden hunger in economically developing countries [8,9]. Globally, 1.7 million people die from micronutrient deficiencies caused by the consumption of micronutrient-deficient or low-nutrient foods [10,11]. Plants consume nutrients from the soil from germination to harvest, leading to the depletion of essential nutrients in agricultural soils [12].

Soil impoverishment can be prevented by using active fertilizers with trace elements during the intensive cultivation of plants [13]. In recent years, many studies have demonstrated the link between micronutrient supplementation

and increased yields, especially in crops containing zinc, manganese, and copper [14,15]. A significant increase in grain yield due to the combined use of zinc microelements with NPK fertilizers shows the importance of trace element fertilizers in plant breeding [16-19]. In Tanzania, NPK fertilizers have been reported to increase rice yield by 1 t/ha, and combined application of NPK and micronutrients by 1.5 t/ha compared to the control [20].

**Methods.** In order to study the process of obtaining NPK fertilizers containing trace element zinc, using the Ostromyslensky-Job method [21], studies were conducted using the method of isomolar sequence according to the ratio of components in the  $ZnSO_4$  and  $NH_4H_2PO_4$  system to theoretically justify the interaction of zinc sulfate with monoammonium phosphate.

In the case where the isomolar sequence method is used, it is carried out by pouring isomolar solutions of research components with the same molar concentration in certain sequential proportions with a constant sum of the initial volumes.

The physicochemical properties of diluted solutions were studied by the isomolar series method to justify the interaction between zinc sulfate and monoammonium phosphate. Based on the ratio of components in the  $ZnSO_4$  and  $NH_4H_2PO_4$  system, pH value, density, refractive index, viscosity and crystallization temperature of the mixture of 0,01 M solutions were measured.

To accomplish this, a solution of zinc sulfate and ammonium dihydrogen phosphate was prepared at 0.01 M and 0.01 M monoammonium phosphate solution was added in increasing amounts to the zinc sulfate solution. Following that, the pH, refractive index, viscosity, crystallization temperature and density of the mixtures were measured. All measurements were made in a water thermostat at a temperature of  $20 \pm 0.1$  °C.

The kinematic viscosity of the solution was measured using a VPZh capillary viscometer with a capillary diameter of 1.16-2.75 mm with an accuracy of  $\pm 0.0001 \cdot 10^{-1}$  m<sup>2</sup>/s. The relative density was determined by the pycnometric method [22].

The pH value of the solutions was expressed using a Bante210 Benchtop pH/mV Meter pH meter.

**Results and discussion.** The results of changes in the physicochemical properties of solutions depending on the ratio of components in the ZnSO<sub>4</sub> and NH<sub>4</sub>H<sub>2</sub>PO<sub>4</sub> system are shown in Figure 1 and Table 1.

The analysis of the "pH - composition" diagram in the ZnSO<sub>4</sub> and NH<sub>4</sub>H<sub>2</sub>PO<sub>4</sub> system shows that as the amount of 0.01 M monoammonium phosphate solution increases from 3 ml to 30 ml, the pH values of the solutions decrease from 3.87 to 3.79 and then increase, as well as the pH in the ratio of [ZnSO<sub>4</sub>(0.01M)]:[NH<sub>4</sub>H<sub>2</sub>PO<sub>4</sub>(0.01M)]=4:6 when the value is 3.20, break is observed.

In the "composition-density" diagrams, the density of the solutions gradually decreases from 0.98459 g/cm<sup>3</sup> to 0.98245 g/cm<sup>3</sup> as the amount of monoammonium phosphate increases and the amount of zinc sulfate decreases, and [ZnSO<sub>4</sub>(0.01M)]:[NH<sub>4</sub>H<sub>2</sub>PO<sub>4</sub>(0.01M)]=4:6 with a composition ratio of 0.98263 g/cm<sup>3</sup>, a change in density value is observed.

Analyzing the data of the "Content - Refractive Index" diagram shows that the refractive indices in the system gradually decrease from 1.3320 to 1.3317 until the [ZnSO<sub>4</sub>(0.01M)]:[NH<sub>4</sub>H<sub>2</sub>PO<sub>4</sub>(0.01M)]=4:6 ratio, and it can be noted that there is a significant breaking point in the diagram. As the amount of monoammonium phosphate in the mixture increases, the value of the refractive index continues to decrease to 1.3316.

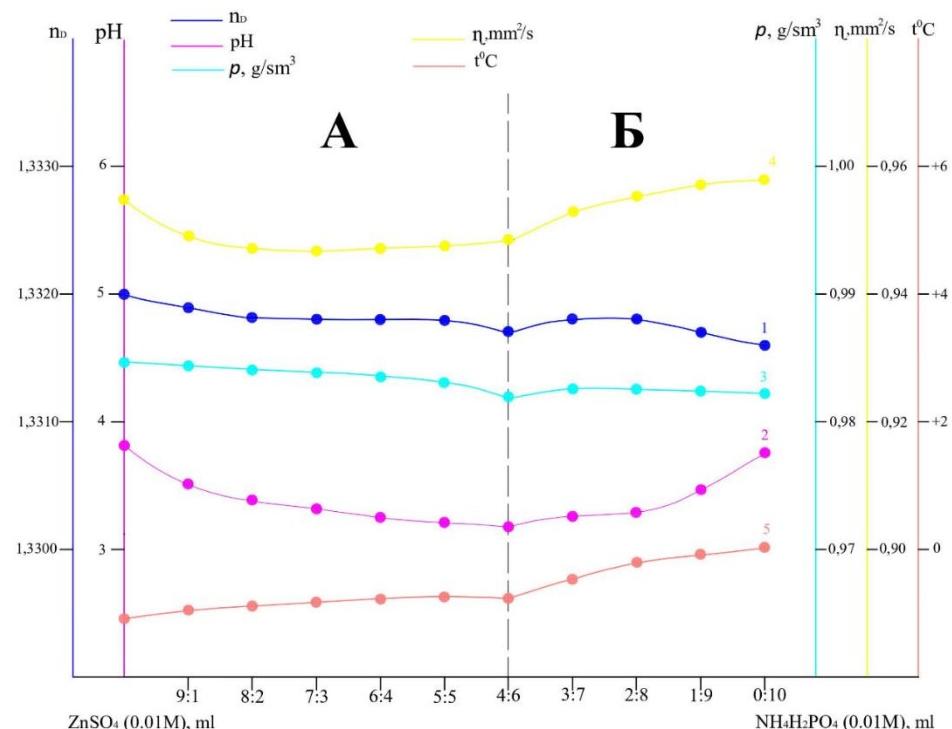
Based on the data of the crystallization temperature in the [ZnSO<sub>4</sub>(0.01M)]:[NH<sub>4</sub>H<sub>2</sub>PO<sub>4</sub>(0.01M)] system of "Composition - crystallization temperature", the ratio [ZnSO<sub>4</sub>(0.01M)]:[NH<sub>4</sub>H<sub>2</sub>PO<sub>4</sub>(0.01M)]=4:6 is characterized by the presence of a clear fracture at a temperature of -0.6 °C.

Viscosity values of the investigated system solution decrease from 0.9549 mm<sup>2</sup>/c to 0.9576 mm<sup>2</sup>/c with a decrease in the amount of 0.01 M zinc sulfate and an increase in the amount of 0.01 M monoammonium phosphate. It is also explained by the presence of a breaking point of 0.9481 mm<sup>2</sup>/c at a ratio of 4:6.

Table 1  
**Changes in physicochemical properties of solutions depending on the ratio of components in the [ZnSO<sub>4</sub>(0.01M)+NH<sub>4</sub>H<sub>2</sub>PO<sub>4</sub>(0.01M)] system**

№	Компонент таркиби		рН	Зичлик г/см <sup>3</sup>	Қовушқоқлик, мм <sup>2</sup> /с	Кристалланиш харорати, °С	Хип синдириш күрсаткичи
	ZnSO <sub>4</sub> , мл	NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub> , мл					
1	30	0	3.87	0.98459	0.9549	-1.0	1.3320
2	27	3	3.49	0.98424	0.9485	-0.9	1.3319
3	24	6	3.39	0.98405	0.9466	-0.9	1.3318

4	21	9	3.32	0.98371	0.9468	-0.8	1.3318
5	18	12	3.25	0.98332	0.9471	-0.7	1.3318
6	15	15	3.23	0.98295	0.9479	-0.6	1.3318
7	<b>12</b>	<b>18</b>	<b>3.20</b>	<b>0.98254</b>	<b>0.9481</b>	<b>-0.6</b>	<b>1.3317</b>
8	9	21	3.22	0.98259	0.9525	-0.4	1.3318
9	6	24	3.26	0.98251	0.9558	-0.2	1.3318
10	3	27	3.45	0.98247	0.9570	-0.1	1.3317
11	0	30	3.79	0.98245	0.9576	0	1.3316



**Figure 1. Changes in physicochemical properties of solutions depending on the ratio of components in the  $[ZnSO_4(0.01M)+NH_4H_2PO_4(0.01M)]$  system**

**Conclusion.** According to the results of the physicochemical characteristics of diluted solutions in the  $[ZnSO_4(0.01M)]:[NH_4H_2PO_4(0.01M)]$  system, i.e., the pH environment, density, viscosity, refractive index and crystallization temperature values, one deviation corresponding to the presence networks of the initial components is observed. Based on the results of the diagram, it is expressed in the ratio  $[ZnSO_4(0.01M)]:[NH_4H_2PO_4(0.01M)]=4:6$ .

From the obtained results, it can be concluded that changes in the physicochemical properties of solutions occur even at the above amount of zinc sulfate and monoammonium phosphate with the composition ratio  $[ZnSO_4(0.01M)]:[NH_4H_2PO_4(0.01M)]=4:6$ . This shows that regardless of the initial concentration of zinc sulfate, when a small amount of monoammonium phosphate is added, a change in the composition of the solution occurs.

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## STUDY OF THE PROBLEMS OF ATMOSPHERIC WASTE WATER COLLECTION AND GREEN FIELD IRRIGATION

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**Abstract:** All over the world today the problem of water scarcity is getting worse. At the moment, we see that in the countries of Central Asia, as well as in our republic, the shortage of water is increasing, the melting of ice reserves is accelerating, the level of reserves of river, stream, lake and groundwater is decreasing, and green spaces are shrinking. One of the most important problems is the prevention of water shortages and the establishment of an effective use of atmospheric wastewater in the water supply of green spaces.

**Keywords.** Atmosphere, wastewater, water treatment, green spaces, irrigation, reservoir, apartment buildings, water collection.

In our country, consistent work is being done in the field of environmental protection, rational use of natural resources, improvement of sanitary and ecological conditions.

At the same time, the results of the analysis conducted in this regard indicate the absence of a comprehensive approach and strategic planning in the implementation of state functions in the field of environmental protection, as well as the insufficient powers of the nature protection body to effectively perform the assigned tasks [1].

The growth of the world's population and industrial enterprises has a direct negative effect on nature, as a clear evidence of this can be seen in the decrease of natural resources. For example, we can see that the water shortage is increasing, the melting of ice reserves is accelerating, the level of rivers,

streams, lakes and underground water reserves is decreasing, and green areas are shrinking. These emerging problems arise from the irregular and purposeless use of natural resources, as well as the fact that the targeted management system of these resources has not been fully implemented [2]. Today, the use of energy and resource efficient devices is of great importance.

Based on the content of the research work, a number of methods were used, such as systematic analysis, comparison, mathematical, statistical, extrapolation, basic experimental research, comparison, remote methods, systematization of the obtained data in graphs and tables.

Today, in the Republic of Uzbekistan, due to the increasing water shortage and the inadequate protection of forests, the number of forest holdings is reduced to 7.7% of the territory of the republic. In order

to protect the environment, to prevent water scarcity and the reduction of green areas, our state has adopted a nationwide state program of green spaces, and practical work is being carried out to establish green spaces and tree seedlings are being planted [3,4,5].

Planting a single tree does not solve this problem, it requires constant care to grow and develop. For the good development of any plants, water takes the main place. We can see in the table below that the amount of water used for irrigation varies depending on the type of plants.

**Table 1**  
**Indicators on water consumption (QMQ 2.04.01.98)**

№	Water consumers	Water consumption l/m <sup>2</sup>	Watering period	The amount of water required for 1m <sup>2</sup> of land in the irrigation season is m <sup>3</sup>	
				2 times a day	1 time per day
1	Sprinkle water on the sidewalk	0,4	In one day 2 times	0,144	0,072
2	Spraying water on the green area	1,4	In one day 2 times in 7 days	0,252	0,126
3	Irrigation of the garden	15	1 time	0,385	

It can be seen from the above table [6] that each plant's irrigation period and water requirement are different, so it is necessary to reduce water consumption and use alternative water sources.

Irrigation of green areas requires an average of 126 l of water per m<sup>2</sup> during the irrigation season. It may seem like a small amount at first glance, but it certainly causes some complications when watering green areas in an area that is not provided with surface water or irrigation channels. The only source used for irrigation here is potable water [7].

Using potable water for irrigation is nothing more than making two problems. For example, the use of potable water for irrigation causes a decrease in potable water reserves, an increase in water losses, a decrease in the pressure in the network, which causes drinking water not to reach the upper floors of houses and end consumers.

Clause 96 of the Resolution No. 194 of the Cabinet of Ministers of the Republic of Uzbekistan dated July 15, 2014 "On approval of the rules for the provision of communal services" allows the use of potable water for watering trees in the following exceptional cases: in the absence

of irrigation water, when the capacity of the ISKH organization is available, and the local state according to the schedule approved by the authorities, it is allowed only at night (from 00:00 to 05:00) [8].

In exceptional cases, the use of drinking water for irrigation also has its own requirements. But consumers do not have a full understanding of this, so in many cases we can see that drinking water is used for irrigation during the day.

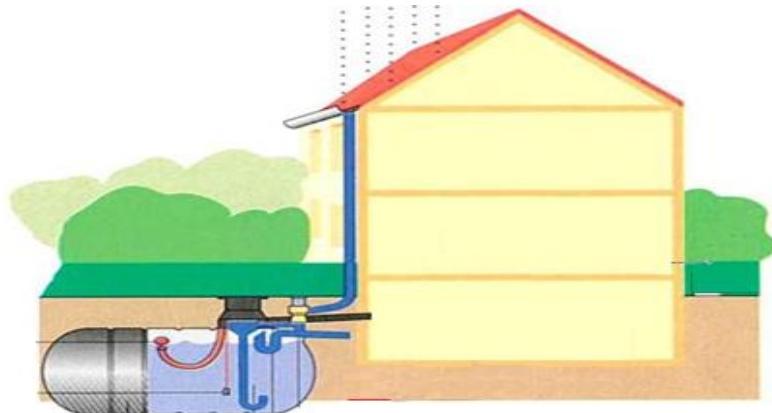
In order to prevent the wastage of drinking water, we can use other alternative sources, that is, we can save and expand existing green areas by collecting and treating atmospheric wastewater and using it as technical water to irrigate technical crops, green areas, and ornamental trees [9, 10, 11, 12, 13, 14].

In our country, up to 50 kg of snow falls on m<sup>2</sup> area and 150-300 ml/m of rain falls. The average duration of rain is 4-6 hours, in some cases it can reach up to 12 hours [15]. In large urban centers without irrigation canals, we can see even partial flooding during the rainy season, which inevitably leads to water accumulation in subways, apartments, basements of high-rise buildings and highways due to the

absence of irrigation canals that drain atmospheric wastewater outside the city.

If we assume that the duration of one rain falls on average is 4 hours, from 36 to 72 liters of atmospheric waste water falls on  $m^2$  of land.

The use of water for landscaping by collecting the water flowing from the roofs of residential houses and multi-apartment buildings in special reservoirs for collecting atmospheric wastewater is effective for increasing and preserving green spaces [16, 17].



**Figure 1. Atmospheric wastewater collection tank**

If we look at the example of the city of Tashkent alone, as of January 1, 2023, there are 41,000 apartment buildings [18], the roof area of each of them is from 200  $m^2$  to 1400  $m^2$  (800  $m^2$  on average). A single rainfall produces 28.8  $m^3$  to 57.6  $m^3$  of atmospheric wastewater, which is enough to irrigate 41,142  $m^2$  of green space once.

Each multi-apartment house has a green area of up to 600  $m^2$ , which shows that it is possible to irrigate the green areas around the house for 34 days with one rainwater.

Today, in order to prevent the depletion of water resources, the widespread use of water-saving technologies and the introduction of re-technical irrigation of crops and green areas using domestic wastewater local treatment technologies is another solution to the problem [19, 20].

**Conclusions and recommendations.** Preventing water

shortages and shrinking of green areas all over the world, and at a time when surface and underground drinking water reserves are decreasing, the construction of reservoirs for collecting water from atmospheric wastewater to irrigate trees and green areas, as well as allowing the use of water for irrigation, is the most important way to prevent water shortages. we can see as one of the main solutions.

Relevant state, scientific and public organizations, multi-apartment housing management service companies, private homeowners, improving and applying technologies for collecting atmospheric water falling from the roofs of social sector facilities and using them for the purpose of watering trees in areas with a shortage of surface and underground water gives a good result, and increases the possibility of preventing water shortage in the rest of the regions.

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## STUDY OF ADSORPTION ISOTHERMS OF POLAR AND NON-POLAR MOLECULES ON SILICA ADSORBENTS

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### Abstract:

**Objective.** The purpose of this research work is to study the adsorption isotherms of mesoporous silica adsorbents, their sorption-structural indicators and their relative surface area.

**Methods.** Adsorption isotherms of mesoporous adsorbents were carried out using the quartz spring balance method in the Mac-Ben-Bakra device. Using this method, adsorption isotherms of silica adsorbents synthesized at different temperatures are obtained. Based on this, information is given about their sorption structure characteristics.

**Results.** During the research, the adsorption isotherms of the samples (230/22, 234/22 and 235/22) showed a steep appearance due to the high amount of adsorption  $P/P_s=0.2$  at low relative pressures. The curves of the adsorption isotherm graph of adsorbents showed that they correspond to type IV of the classification proposed by Brunauer. The main absorptions of adsorption of benzene molecules on silica adsorbents: 24.1% in 230/22, 19.7% in 213/22, 24.2% in 234/22, -27.9% in 235/22, -23.9% in 244/22, -21.6% in 245/22. corresponds to the amount of monolayer capacity of adsorbents.

**Conclusion.** Adsorption isotherms were studied in the presence of polar molecule water and nonpolar molecule benzene as adsorbate on silica adsorbents . Based on the isotherm curves of synthesized silica adsorbents, it was determined that they belong to type IV according to Brunauer's classification. The sorption-structural characteristics studied during the research and the data obtained on the volumetric pores gave results on their important dimensions such as micro- and mesoporosity, radius size of the pores, as well as the relative surface area.

**Keywords:** isotherm, benzene, water, Mac-Ben-Bakra, micropore, mesopore, specific surface area, volume of pores, adsorption.

**Introduction.** Today, adsorbents are widely used in various fields of production. The main participant of the adsorption process is the adsorbent product, which

enters our country as an imported product. In the synthesis of sorbents, their production on the basis of local raw materials, especially with the help of waste, plays an important role in solving the problem of environment and ecology, as well as in solving the problem of cost and economy. To date, adsorbents are based on various raw materials, including lignite and hard coal [1-3], activated wood of various trees [4-7], waste from the food industry [8-10], as well as zeolites [11-12] and bentonite. with the help of adsorbents obtained [13-15] are widely used in various industries. In the production of adsorbents, issues of ecology and environmental protection are provided based on the use of waste.

The raw material is important when obtaining the sorbent, so it is important to select it taking into account its chemical composition and adsorbing properties. For this reason, in this research work, to obtain mesoporous adsorbents, it is important to select waste raw materials containing silica - rice husk [15].

From an analysis of the literature, it is clear that the authors [16] proposed a technology for extracting silicon dioxide by burning rice husks (by pyrolysis method), processing residual ash, recycling with acid or alkali. The main criterion was the use of a simple and cheap technology for extracting  $\text{SiO}_2$  in a chemically pure state. In a previous research work [15], chemically pure silicon oxide was obtained, and in this work its adsorption properties were studied, including the sorption-structural index using an isotherm, as well as the volumetric theories of its pores.

**Methodology.** Adsorption isotherms of mesoporous adsorbents based on silica and chitosan synthesized at different temperatures were determined using a Mac-Ben-Bakra device using a quartz spring balance method. The device is equipped with a highly sensitive quartz

spiral. Its sensitivity level is  $1.78 \cdot 10^{-3}$  kg/m. Samples of adsorbents in an adsorption flask (test tube) were kept in a water thermostat at a temperature of 20°C with an accuracy of 0.1°C. The structure of the device and the main working parts of the working system are structured as follows: - columns with quartz springs (equipped with cups in which the studied samples of adsorbents are placed, measured with an accuracy of 1 g), - a fore vacuum pump (brand VN - 461M, - a diffusion pump (residual pressure in the system is  $1.33 \cdot 10^{-3}$  Pa until a vacuum is created, the pressure in the system is controlled using a screw thermo-vacuum gauge (brand VIT2), U-shaped pressure gauges - a trap (it is designed to trap various gases and vapors water in a system with liquid nitrogen), ampoules in which adsorbents are placed, and taps for separating parts of the device from each other. Fore vacuum and diffusion pumps produce up to  $1 \cdot 10^{-5}$  mm Hg. vacuum in the adsorption device. The pressure difference in U-shaped pressure gauges is measured using a cathetometer type B630. The cathetometer has a resolution of 0.05 mm. The samples prepared for the study were ground in an agate mortar to a powder and, after thorough mixing, were weighed and placed in a cup. The pressure in the system is stabilized by evacuation for 6-8 hours. Benzene and water obtained as adsorbate were purified and dried under vacuum conditions before being used in adsorption, its vapor pressure was first frozen and then heated to release dissolved gases from it until it became the same as the pressure data vapors indicated in the tables for pure benzene and water, and studied its adsorption.

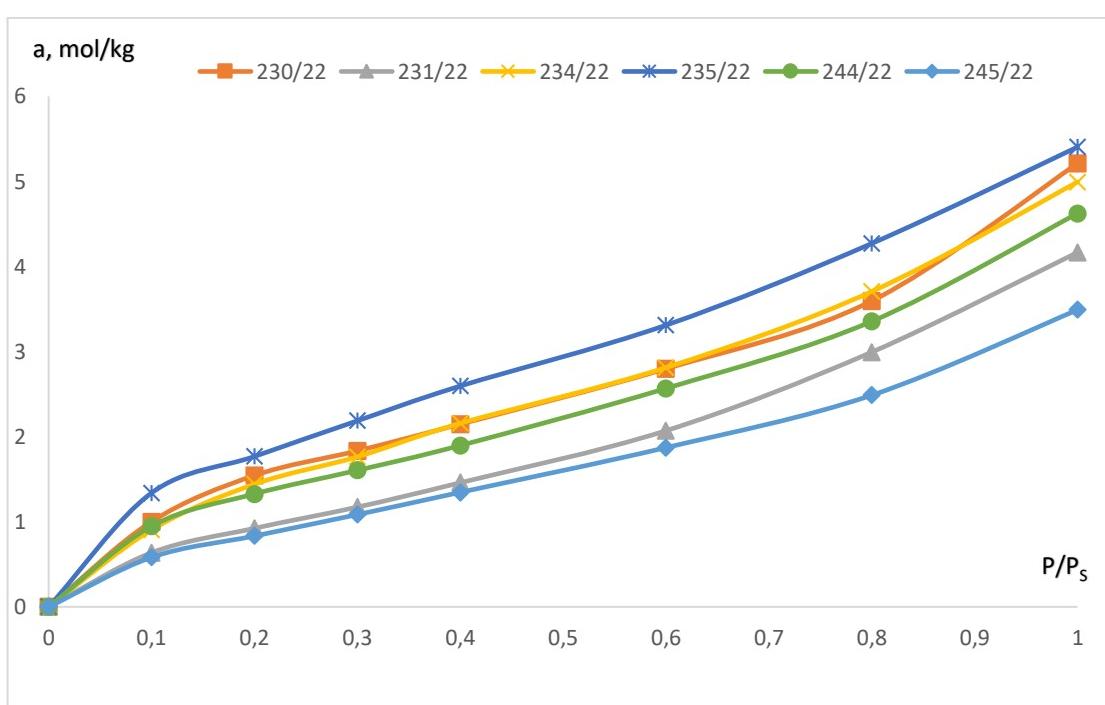
**Results and discussion.** The device was cleaned and dried under vacuum before adsorption of the samples with selected organic benzene and non-polar water vapor molecules as adsorbate. After

freezing and then heating until the vapor pressure inside the device equals the vapor pressure data for pure benzene and water given in the tables, the adsorption process was studied after the release of dissolved gases.

It can be seen from the adsorption isotherms in the mentioned systems that the amount of adsorption rises sharply from the zero value of the relative specific

pressure to the value  $P/P_s \approx 0.4$ , and then the adsorption slowly increases and approaches the saturation state.

The sharp appearance of the adsorption isotherms at such a low relative pressure ( $P/P_s \approx 0.4$ ) is a reason to conclude that benzene vapors are adsorbed on surfaces with a high adsorption potential in the initial fillings.



**Figure 1. Benzene vapor adsorption isotherm on silica adsorbents**

In the course of research, it is observed that the isotherm is steep due to the high adsorption amount of  $P/P_s = 0.2$  in samples synthesized from silicon oxide and chitosan (230/22, 234/22 and 235/22) at low relative pressures. This shows that the curves of the adsorption isotherm of all adsorbents obtained during the experimental preparation belong to type IV of the classification proposed by Brunauer.

The appearance of adsorption isotherms depends on the properties of the adsorbent and the absorbed substance adsorbate and the forces of interaction between them. First, it is related to the size, nature and charge of the exchangeable

cations in the samples, and secondly, it is related to the specificity of the interaction of non-polar benzene molecules with modified adsorbents, i.e., the change in the hydrophilic and lyophilic nature of the adsorbents. In the synthesized sample 235/22, the adsorption amount of benzene vapors is higher compared to other adsorbents, due to the interaction of non-polar benzene molecules with cations between the adsorbent layers. During the research, it can be seen that the relative pressure of the adsorption isotherm increases again in the range  $P/P_s = 0.6-1.0$ . Adsorption of adsorbate molecules into adsorbent pores indicates that adsorption

of benzene vapors in these samples occurred as a result of capillary condensation in secondary pores.

From the structural adsorption parameters of adsorbents, the specific surface area ( $S$ ) was determined using the Brunauer-Emmett-Teller (BET) theory

equation. If  $P/P_s /a(1 - P/P_s)$  is placed on the ordinate axis and  $P/P_s$  values on the abscissa axis, it is observed that straight line coordinates are generated. The specific surface area of adsorbents was calculated using the following formula:

$$S = a_m \cdot N \cdot \omega$$

Where:  $S$ -relative specific surface ( $m^2/g$ );

$a_m$ - monomolecular layer ( $mol/kg$ );

$N_A$ - Avagadro's number;

$\omega$ - surface area occupied by one molecule ( $nm^2$ )

Based on the isotherms of benzene vapor adsorption on synthesized silica adsorbents, the monolayer capacity  $a_m$ , saturation volume  $V_s$  (or adsorption  $a_s$ ) and their relative surfaces  $S$  were calculated from the important indicators of adsorbents. The obtained results are presented in Table 1.

Table 1

**Results of sorption-structural indicators of benzene vapor adsorption on cermene earth adsorbent samples**

Adsorbent samples	Monolayer capacity, $a_m, mol/kg$	Relative surface area, $S \cdot 10^{-3}, m^2/kg$	Saturation adsorption $a_s, mol/kg$
230/22	1.257	302.76	5.21
231/22	0.820	197.51	4.16
234/22	1.207	286.78	4.99
235/22	1.510	363.61	5.40
244/22	1.108	266.73	4.62
245/22	0.754	181.60	3.49

The main part of the absorption of benzene molecules in the synthesized adsorbent samples is 24.1% in the 230/22 adsorbent sample, 19.7% in the 213/22 adsorbent sample, 24.2% in the 234/22 sample and -27.9% in the adsorbent sample 213/22. In the adsorbent sample 235/22, in the adsorbent sample 244/22 - 23.9% was observed, and in the 245/22 sample -21.6%, which corresponds to the monolayer capacity. The observed increase in the relative surface area and the size of the adsorbent adsorption in the following samples of synthesized adsorbents: 245/22-231/22-244/22-234/22-230/22-235/22. Such a change in

specific surface area and saturation adsorption in silica adsorbent samples depends on their chemical composition and the conditions during the synthesis process. Adsorption isotherms of benzene vapor in the samples and the volume of micropores ( $W_0$ ) of adsorbents, adsorption volumes for saturated states ( $V_s$ ) and the volume of mesopores were determined by the formula  $W_{me} = V_s - W_0$  using the equation of the theory of volumetric filling of micropores (VTFM). The average radius of the pores was calculated according to the formula  $r_{av} = \frac{2 \cdot V_s \cdot 10^4}{S}$ . The obtained results are presented in Table 2.

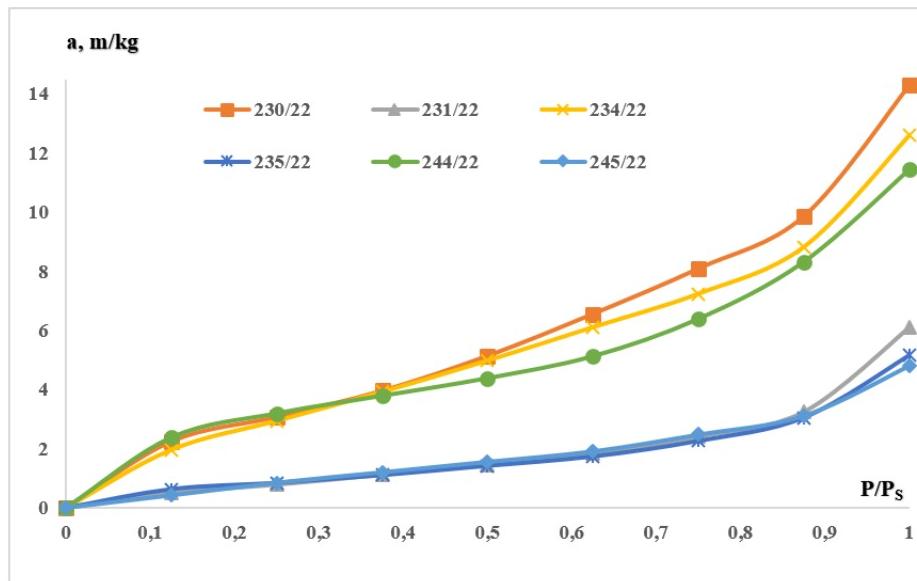
Table 2

## Pore volume indicators based on the results obtained from the adsorption of benzene vapors on adsorbents

Samples	Micropore size, $W_0 \cdot 10^3$ , m <sup>3</sup> /kg	Saturation volume, $V_s \cdot 10^3$ , m <sup>3</sup> /kg	Mesopore size, $W_{me} \cdot 10^3$ , m <sup>3</sup> /kg	Average pore radius, $r_{av}$ , nm
230/22	0.297	0.461	0.164	3.05
231/22	0.222	0.369	0.147	3.74
234/22	0.284	0.442	0.158	3.08
235/22	0.336	0.479	0.143	2.63
244/22	0.265	0.410	0.145	3.07
245/22	0.195	0.309	0.11	3.41

From the analysis of the obtained results, it can be seen that the size of micropores in adsorbent samples 230/22, 234/22, 235/22 and 244/22 is close to each other, but in sample 230/22, the amount of mesopores is relatively large, and in sample 235/22, the saturation adsorption volume is relatively high. It was found that the remaining two adsorbents have small micropores and saturation adsorption capacity. All adsorbents are among mesoporous ( $2 < r < 50$  nm) adsorbents according to the classification proposed by M.M.Dubinin according to the average radius of their pores.

In addition to the benzene vapor molecule, the adsorption isotherm of water vapor, a polar molecule, was selected as an adsorbate in the synthesized adsorbent samples. The obtained results are presented in Figure 2.



**Figure 2. Adsorption isotherms of water vapor on silica adsorbent samples**

In all systems studied during experimental studies, the isotherms first increase sharply to a relative pressure  $P/P_s=0.3$ , and then slowly increase in the range  $P/P_s = 0.4-0.7$  and in the saturation

state ( $P/P_s = 0, 7$ )  $P_s = 0.8-1.0$ ) increased sharply again. The initial stages of adsorption proceed when water molecules form complexes with cations contained in adsorbents in the form of  $K^+(H_2O)_n$ . In the

next stages, adsorption takes place between centers and pores with a high adsorption potential, and the last stages take place in the case of capillary condensation. The results of studying the pore structure of mesoporous dispersed solids are often associated with the interpretation of type IV adsorption isotherms. This type of isotherm is mainly characterized by absorption in mesoporous areas. At low pressure, the initial parts of type IV and type II isotherms become similar. But type IV isotherms shift upward from a certain point of pressure, and its slope decreases at higher pressures during the study. When approaching the saturated vapor pressure ( $P/P_s=1$ ), it can be observed that the value of adsorption increases significantly. Dipole moment values of adsorbates (polar and non-polar),

the nature and structure of pores in adsorbents, the interlayer distance formed between these pores and their volumes, and the size of the adsorbent radius have a great influence on the amount of adsorption. It was observed that the dipole moment of polar water vapor molecules is higher than the dipole moment of non-polar benzene molecules in all synthesized adsorbent samples. In particular, it was determined that the adsorption amount of the 230/22 adsorbent sample against benzene vapor is equal to 5.21 mmol/g, and against water vapor is equal to 14.30 mmol/g.

Therefore, the effect of the electronic nature of the adsorbent is considered significant when using adsorbents in adsorption processes.

Table 3  
**Structure - sorption indicators of water vapor adsorption on silica adsorbents**

Samples	Monolayer capacity, $a_m$ , mol/kg	Relative surface area, $S \cdot 10^{-3}$ , m <sup>2</sup> /kg	Saturation adsorption $a_s$ , mol/kg
230/22	2.38	154.71	14.30
231/22	0.645	41.91	6.11
234/22	2.304	149.79	12.61
235/22	0.645	41.91	5.16
244/22	2.347	152.60	11.45
245/22	0.669	43.52	4.81

The basis of the results of isothermal polar molecular water and silica adsorbents by the studied sorption-structural properties, the obtained results are presented in the table. 3. In the presence of isotherms of water vapor adsorption on silica adsorbents, the monolayer capacity  $a_m$ , saturation volume  $V_s$  (or adsorption  $a_s$ ), and their relative surface areas  $S_{sp}$  were calculated using important parameters of the sorbents.

Among the obtained silica adsorbents, the specific surface area ( $S_{sp}$ )

and saturation volume ( $a_s$ ) of sample 230/22 with a mass of 200 kDa, synthesized at a temperature of 400°C, turned out to be the largest. It can also be seen that the specific surface area ( $S_{sp}$ ) and saturation volume ( $a_s$ ) are high in the 244/22, 500 kDa sample at 400°C. It can be seen that the specific surface area ( $S_{sp}$ ) and saturation volume ( $a_s$ ) of sample 230/22 are the highest among the obtained silica adsorbents.

Table 4  
**Indicators of pore volume during adsorption of water vapor on silica adsorbents**

Samples	Micropore size, $W_0 \cdot 10^3$ , m <sup>3</sup> /kg	Saturation volume, $V_s \cdot 10^3$ , m <sup>3</sup> /kg	Mesopore size, $W_{me} \cdot 10^3$ , m <sup>3</sup> /kg	Average pore radius, $r_{av}$ , nm
230/22	0.145	0.257	0.11	3.33
231/22	0.050	0.110	0.06	5.25
234/22	0.134	0.227	0.09	3.03
235/22	0.043	0.093	0.05	4.43
244/22	0.119	0.206	0.09	2.70
245/22	0.047	0.087	0.04	3.99

During the research, the adsorption isotherms of the samples (230/22, 234/22 and 235/22) showed a steep appearance due to the high amount of adsorption  $r/rs=0.2$  at low relative pressures. The curves of the adsorption isotherm graph of adsorbents showed that they correspond to type IV of the classification proposed by Brunauer. The main absorptions of adsorption of benzene molecules on silica adsorbents: 24.1% in 230/22, 19.7% in 213/22, 24.2% in 234/22, -27.9% in 235/22, -23.9% in 244/22, -21.6% in 245/22. corresponds to the amount of monolayer capacity of adsorbents.

In this case, the amount of benzene vapor adsorption does not differ greatly due to the fact that the composition, structure, and nature of the synthesized adsorbents are almost similar to each other. The synthesized 235/22 sample adsorbent is characterized by a higher adsorption amount of benzene vapors compared to other adsorbents, higher active centers between adsorbent layers and higher pore size compared to other adsorbents.

**Conclusions.** Adsorption isotherms were studied in the presence of polar

molecule water and nonpolar molecule benzene as adsorbate on silica adsorbents . Based on the isotherm curves of synthesized silica adsorbents, it was determined that they belong to type IV according to Based on the isotherm curves of synthesized silica adsorbents, it was determined that they belong to type IV according to Brunaeer's classification. The sorption-structural characteristics studied during the research and the data obtained on the volumetric pores gave results on their important dimensions such as micro- and meso-porosity, radius size of the pores, as well as the relative surface area.

It was found that the volume of micropores ( $W_0$ ) of samples of silica adsorbent synthesized at a temperature of 400°C, as well as the adsorption volumes ( $V_s$ ) for their saturated states, increased.

According to the results of adsorption of vapors of water molecules, the resulting adsorbents can be used as adsorbents for the purpose of purifying industrial products in various industries from polar compounds.

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## MECHANICS AND ENGINEERING

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## USING PARALLEL SERVICE TECHNIQUES TO CONTROL SYSTEM LOAD

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### Abstract:

**Objective.** At the moment, remote service systems are being used more frequently to implement work and study activities. This calls for the accomplishment of activities including enhancing the fundamentals of remote systems using information and communication technologies, which are the system's constituents, picking the appropriate categories of services, and picking acceptable system-related hardware. Choosing appropriate service delivery techniques for distance education systems is a topic that is discussed in this article. Additionally, it was discovered that forming the system component using techniques appropriate for the service task could improve the service's quality and cut down on the amount of time needed to provide it.

**Methods.** This article uses threading, process and asynchronous programming methods of service provision. Also, the advantages of responding to requests by these methods were analyzed.

**Results.** As a result of the research, the dependence of the above service methods on the types of requests and the importance of their role in reducing the service time are stated.

**Conclusion.** In conclusion, it can be said that the use of service methods in service systems is not only important in the correct organization of services, but also in reducing the time of service requests. This is important for system users to be satisfied with the quality of service.

**Keywords:** remote service system, service methods, threading, processes, asynchronous programming, client-server system.

**Introduction.** These days, remote service solutions are always evolving. This is an opportunity to provide users with services that are more practical. In all spheres of business, including education, remote services are becoming more prevalent. This method has been progressively enhanced, particularly since the COVID-19 pandemic, and it has now developed into a distinct field of instruction. The number of its users is currently growing daily [10]. Typically, remote education uses information and communication technologies (ICTs) in all educational processes and enables users to engage in online training in the field of their choice regardless of location [10]–[11]. The demand for information and communication technologies is consequently increased significantly. To put it another way, choosing the right hardware for any remote service systems,

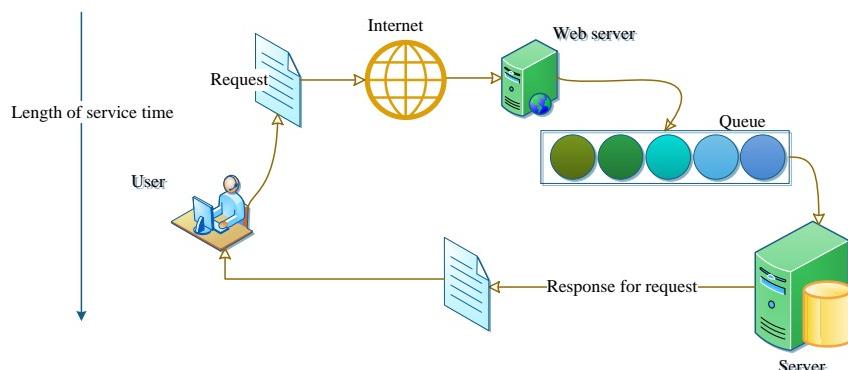
setting up Internet connections, and choosing the right ways to handle user requests all play a crucial role in this. This is not achievable in remote systems since in the typical harvesting operations, all training sessions are planned in accordance with the training audiences. Because users participate in the educational process through a single system in convenient circumstances for themselves when the educational process is structured through remote platforms. This means that as a result of the increase in the number of users of the remote system, the load on the dedicated service device for the system increases. Therefore, in the organization of such systems, it is appropriate to pre-estimate the probability of an increase in users, to determine the compatibility of the devices selected for the system with the number of users and the number of requests, and to choose service

methods depending on the types of service.

**Materials and methods.** Currently, the system goes through the following processes as it responds to user requests: First, as remote systems take the form of web applications, the user logs in and creates a preliminary connection with the system by entering the system address in the browser. The next request to enter the system via permission is then sent. He identifies what function he is in and begins servicing the system in the sequence that relates to that position by providing the user's login and password to the system server as part of the authorization section of the request. The user makes multiple requests to the system in the following phases. In this situation, the user's requests might be for changing various settings, gaining access to other subject departments, using certain subject materials, taking part in various debates, uploading or downloading files, or performing control activities. The system creates an appropriate answer to the request based on the type of requests given to it. As part of the answer-formation process, the database is searched for the relevant data, which is then presented to the system's required areas. The address of the user who submitted the request will

receive the data that was collected. The data sent must be in the format designed for the network, and it is compressed using a number of different sending philosophies and sending speeds. This implies that it is necessary to make the user's device usable once the response has reached it.

Additionally, the service device encounters the issue of an increase in response time to requests due to an increase in requests during the deployment of these activities. When serving requests, this results in the loss of some of them. Since incoming requests happen at random times and are only fulfilled when the service device is free, the theory of mass service states that requests are fulfilled when they are. The reason being that each user uses the equipment or software they require at a time that suits them. Aggregated procedures, waiting or conditional loss, and transparent loss can all be used to handle the flow of requests that users generate. Each request's service time is unique and assigned at random [1]. The number of requests in the system at the time the user sends a request, the number of requests in the queue, and whether or not service devices are busy are all represented by this value. The time it takes to respond to each request therefore relies on when it enters the system.



**Figure 1. Service procedure for user requests**

The service method, the speed at which the device responds to requests, and the speed of the Internet connection are

some of the other elements that influence the service time. The usage of parallel service methods for requests is becoming

common, and service methods are one of the key influencing variables in this context. Because remote systems are maintained one client at a time, the service provider and the typical turnaround time for requests directly affect how quickly a problem is resolved. In remote systems, several users can send requests and use the system simultaneously. According to [2] and [3], this condition results in an increase in service time and the system is unable to serve the customers as soon as they anticipate due to the rise in users or requests in the system. When this occurs, web servers employ load-management strategies that enable the parallel processing of many requests. Several approaches of controlling the load entering the system are now in use, and they are described below.

- Threading;
- Processes;
- Asynchronous programming.

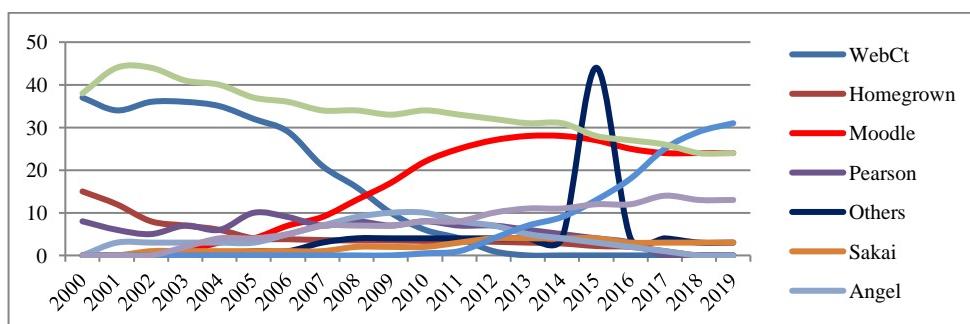
While providing quick responses to user requests is essential, providing excellent service to multiple users simultaneously is also necessary in remote systems support. The foundation of a convenient service for system users is thus

the construction of this component of the system based on the type of service that is appropriate for them, depending on the types of services in the system [4]. As a result, even when the system is under a heavy demand, user requests can be processed quickly and effectively [5, 8, 12].

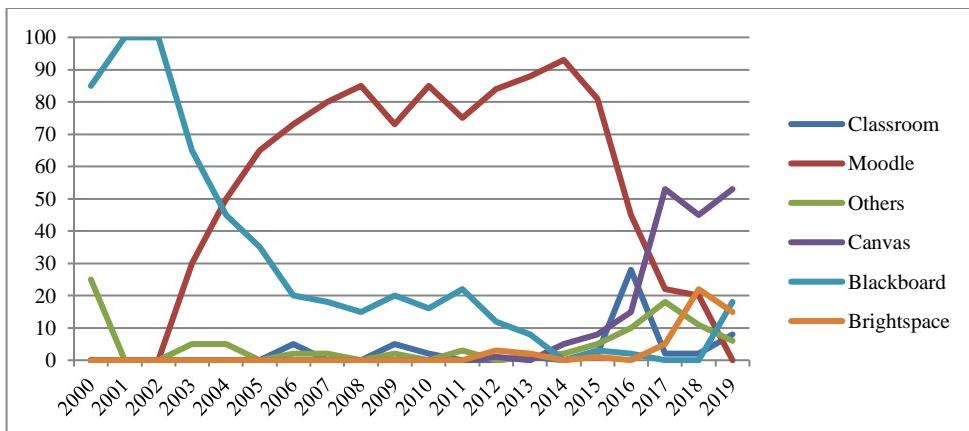
The system's service device is also the most crucial element in how quickly requests are fulfilled, and whether or not it is enough for the load on the system has a direct impact on how quickly requests are fulfilled. This therefore causes a variety of delays, including the inability to fulfill requests. This in turn has an impact on where various mistakes originate, whether information is lost throughout the updating process, and, of course, how quickly and well services are given in response to user requests. Users have noticed that server overloading and failure are the two most prevalent issues with the system server. These issues are some of the ones that are currently being watched the most.

#### **Analysis using remote systems.**

Additionally, a lot of remote learning organizations exist today in the sphere of education, and the indications of their use have altered as a result of their growth and the aforementioned issues. [9] (Fig. 2).



a)  
**Application of distance learning platforms in North American education**



b) Application of distance learning platforms in European education

Figure 2. The indicator of the use of distance education platforms by years

As was already established, the systems' responsiveness and level of user assistance are seen as the primary causes in this situation. These systems are being employed extensively throughout all educational institutions and help to advance the distant learning process. Because it offers its services for free, many organizations increasingly heavily rely on

the Moodle system in particular. For example, TST University has developed its own style of distance learning and uses the Moodle platform to build learning processes. There are more and more signs that it is being used. If we simply consider the time of the 2021–2022 academic year, we can observe that the following was the indicator of its use (Fig. 3).

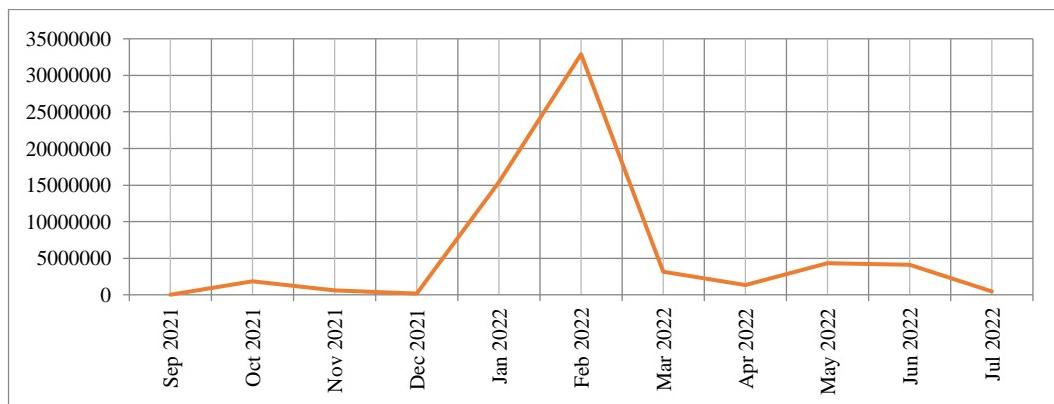
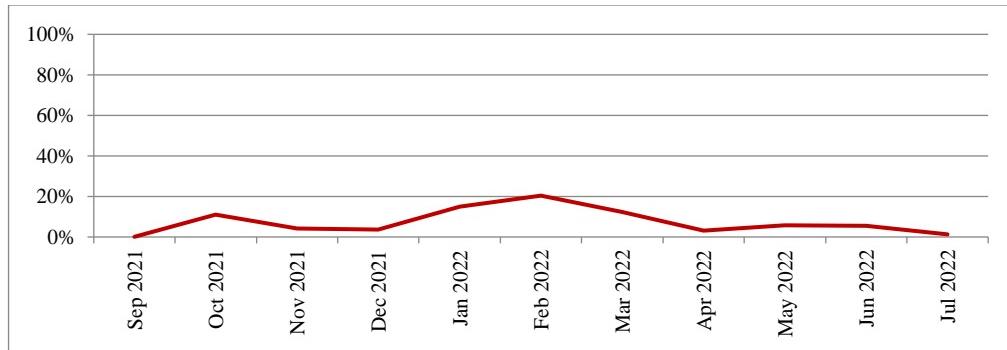


Figure 3. Indicator of the number of requests in the 2021-2022 academic year

Additionally, it should be emphasized that the peak period for these requests was during the students' exam times, when they were most frequently noticed. This in turn affected the lengthening of the response

time to requests and the accomplishment of the desired results from controls. The rate of requests lost during this time was as follows (Fig. 4).

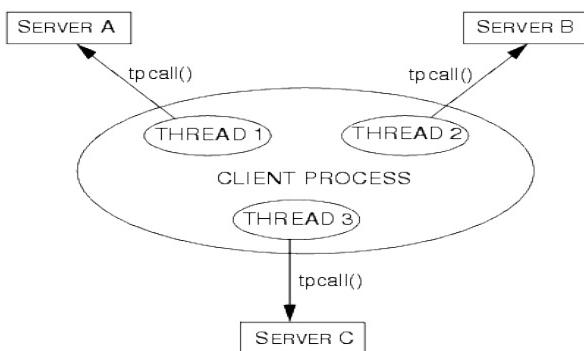


**Figure 4. Query loss rate**

**Service provision methods.** The approaches for service parallelization discussed above are frequently employed to solve this service time issue. The following operating principles underlie these approaches, which are chosen depending on the services they provide:

Working with high-load systems often involves threading. This technique will also make it feasible to put the web server in parallel operating mode, which will increase the workload on the server. Typically, web servers process incoming requests one at a time, responding to the

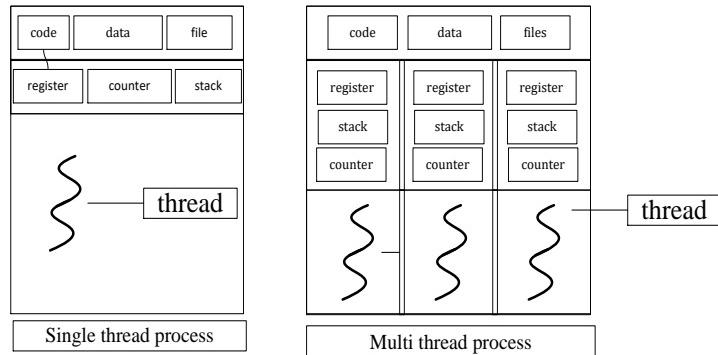
previous request before serving the subsequent one [5]. In addition, threading allows the web server to generate a distinct thread for each request as soon as it detects one coming to the system and attach that request to that thread when it really arrives at the system. This request will be handled by a thread, which will also produce the response and transmit it to the user. As a result, the web server will be able to handle more requests while providing faster service to fewer consumers [4], [5] (Fig. 5).



**Figure 5. Serving requests in a threading manner**

Similar to threading, processes allow you to reply to requests simultaneously. But process, in contrast to threading, has a broader definition. In other words, the process is a way to achieve parallelism in the handling of requests, where each request may be handled by one or more

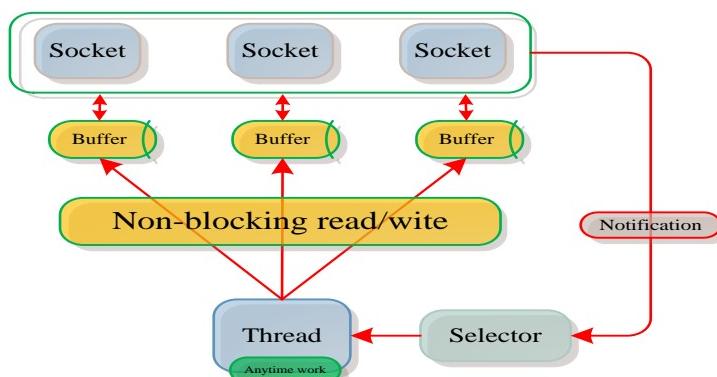
threads. A process is also seen as one that has the ability to operate independently within the system and provide responses to requests by allocating the incoming requests to its thread(s) [4]. This plays a significant role in speeding up request responses.



**Figure 6. Service requests in the process method**

Another popular method for handling requests is asynchronous programming. Asynchronous programming is typically used to increase service delivery and boost

system performance [1], [6]. The asynchronous programming technologies listed below are used to do this:

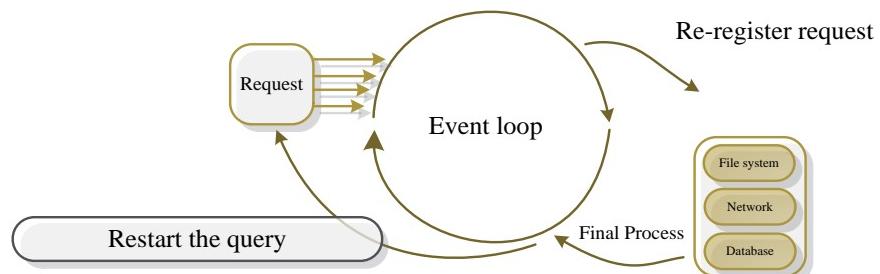


**Figure 7. Operation of a non-blocking I/O asynchronous system**

- Web servers may handle many requests without preventing the completion of other tasks by using input-output operations (non-blocking input and output) [7]. Additionally, it enables the system to accept additional requests before concluding one request's response.

- A system is continually run using an event-driven architectural paradigm based

on various circumstances. The request arrival rate, request response approximation, and time-based versions of this model all make extensive use of it [6], [8]. This in turn helps to handle requests as they enter the system, preventing a number of pauses brought on by requests.



**Figure 8. Process of event-driven architecture system**

**Results.** Appropriateness of service delivery techniques for various service kinds Every one of these service delivery techniques is typically applied in every system. In this instance, service methods are chosen in accordance with the task carried out by a system component. The efficiency of the service delivery techniques is crucial in this situation. A distance learning platform is an illustration of a multi-functional remote service system. These systems offer customers a wide range of services, including the ability to participate in video conferences, work with files, ensure data synchronization between the user and server sides, and perform inspections. The methods used by service organizations to handle various requests are not the ideal, though. As a result, a different service technique is chosen for each kind of service.

As a result, it is feasible to speed up the process of serving requests while also handling more of them. As a result, it becomes possible to handle additional

requests without switching out system components.

**Conclusion.** In remote systems service, while requiring fast service to user requests, it also requires quality service to many users at the same time. This is related to several factors, including the service method, the speed of the device's response to requests, and the speed of the Internet connection. Therefore, the formation of this part of the system based on the type of service that is suitable for them, depending on the types of services in the system, is the basis of convenient service for system users, which in turn leads to a reduction in the speed of responding to requests. This serves as the foundation for quickly responding to user queries even when the system is under a heavy load. Knowing which types of services are appropriate for which types of services is crucial for this. Additionally, choosing the right devices for the system and organizing its operating principles correctly will result in high-quality service for a long period.

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## DEVELOPMENT OF EFFICIENT CHAIN TRANSMISSION CONSTRUCTION BASED ON ANALYSIS OF CONSTRUCTIVE CHARACTERISTICS OF CHAIN DRIVES OF TECHNOLOGICAL MACHINES

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**Abstract.** In the article, the constructions of roller chain transmissions with a new composition, which work smoothly, have high durability, and have a longer service life, are developed for the drives of technological machines for the production of oil from plants. It is proposed to use the proposed extension structures in the handling of the seed distribution drum in the hopper.

**Keywords.** Chain, drive, sprocket, transmission, leader, driven, tension, roller, roller, inner ring, outer ring, ring, component, belt, pulley, impact forces, noise, flat.

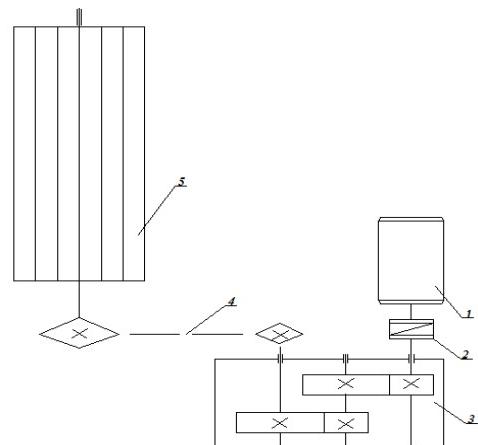
**Introduction.** In Uzbekistan, since ancient times, vegetable oil has been extracted from the seeds of sesame, flax, indow, safflower, cottonseed, and poliza crops in oil mills. Comprehensive measures are being implemented in our republic to modernize and re-equip plant oil plants, to increase the profitability of production and processing of oil products, and at the same time, the competitiveness of manufactured products. In the direction of the conducted research, the task of improving the operation of oil-producing

technological machines and the development of effective resource-efficient transmission structures was set.

**Analysis of supply drum management.** The seed chamber is served by a feeder of a special construction with mechanisms that increase or decrease the seed depending on the density of the seed bed during the linting period to distribute the seeds evenly. Figure 1 shows the overview and kinematic scheme of the seed distribution device in the bunker.



Seed distribution drum drive,



Kinematic diagram of distribution drum operation

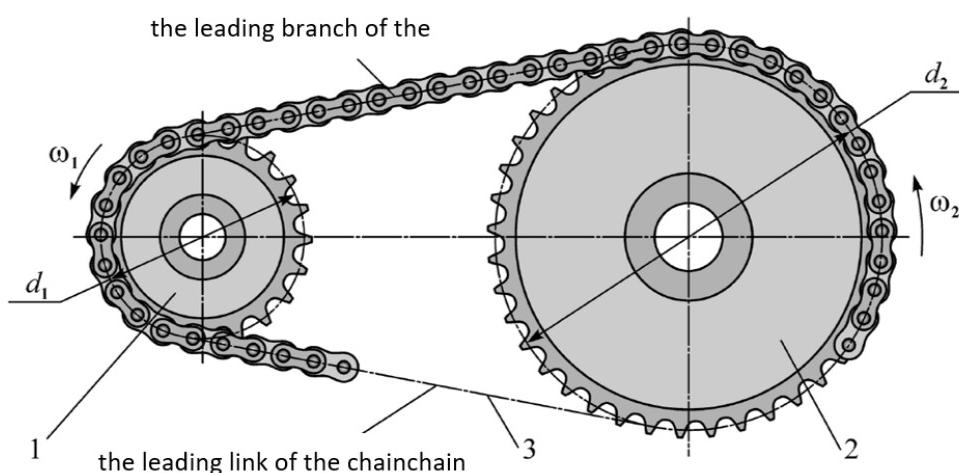
**Figure 1. Seed distribution device**

The drive to the seed-distributing drum is transmitted by a chain drive. A mechanical transmission that transmits movement from one shaft to another using a chain is called a chain drive (Fig. 2). Chain drives are widely used in agriculture, lifting vehicles, textile and printing machines, motorcycles, bicycles, automobiles and drilling equipment. Chain drives mainly allow transmission of up to 100 kW at a speed of 15 m/sec. In special devices, this indicator provides the ability to

transmit 500 kW of power at a speed of 30...35 m/s [1-4.]

There are three types of chain transmissions according to the speed of transmission:

slow moving  $v = 2 \text{m/sec}$ ;  
moving at medium speed  $v = 2 \dots 6 \text{m/sec}$ ;  
fast moving  $v > 6 \text{m/sec}$  can be divided into slow-moving chain drives are used open and lubricated from time to time (for example, in bicycles).



**Figure 1.2. Bushing-roller chain drive construction**

The following advantages have led to the widespread use of chain transmission:

- use in a range with a large inter-axle distance;
- small overall dimensions compared to belt drive;
- absence of sliding phenomenon due to having a single kinematic connection;

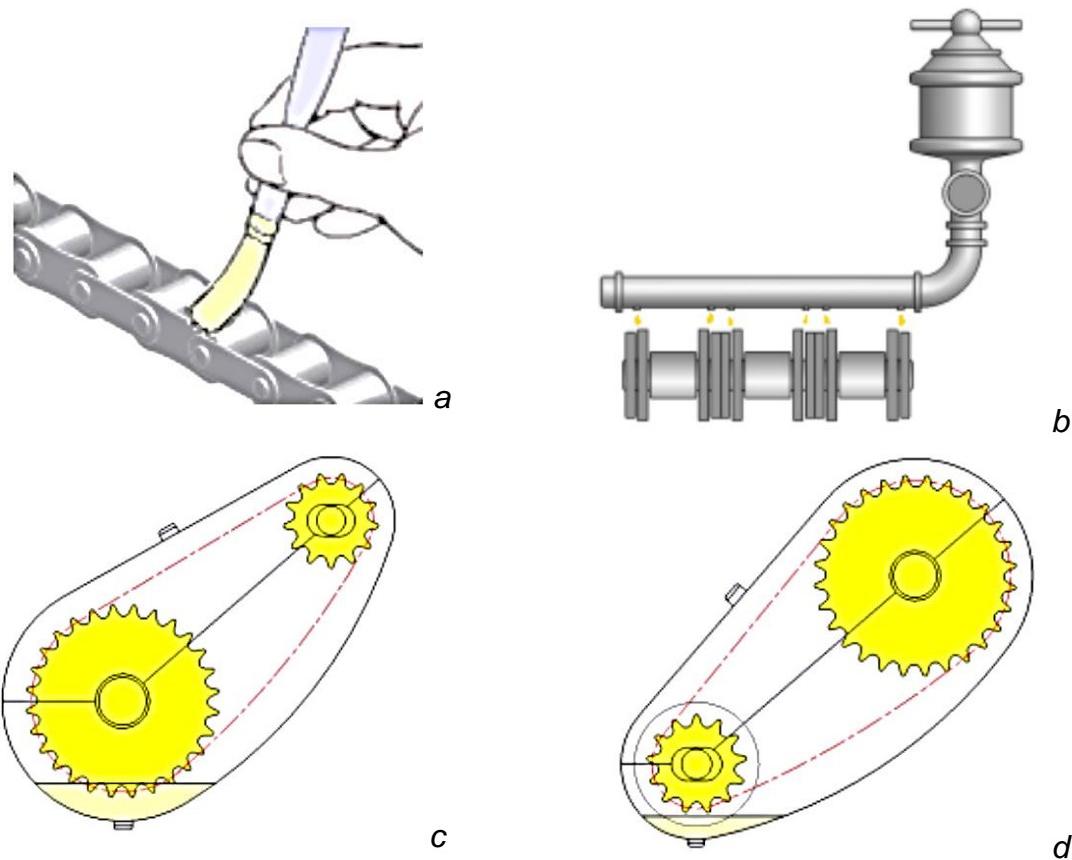
- high coefficient of useful work;
- small force falling on the support of transmission shafts;
- transmission of motion to several shafts;
- it is possible to emphasize the ease of replacing the chain.

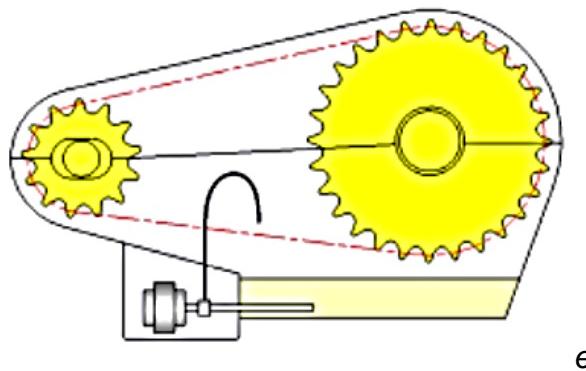
As disadvantages of extension:

- wear of chain elements due to friction in kinematic pairs;
- periodic change of transmission ratio and chain speed in cases where the number of sprocket teeth is small;
- the difficulty of making chain elements with high precision;
- it can be emphasized that the processes of lubrication and adjustment must be under constant control.

Chain drives are used in closed mode when used at high speeds, and are equipped with a protective case in accordance with external dust and other safety requirements. At the same time, the chain is lubricated by continuous dipping or spraying. Adequate lubrication of the chain ensures a long service life. Gear lubrication: manual (Fig. 3 a), drip

lubrication (Fig. 3 b), oil bath (Fig. 3 c), disc lubrication (Fig. 3 d) and power (with a pump) lubrication (Figure 3 e) styles are available. The influence of the mutual kinematic friction force of chain transmission elements is high. If the chain drive is used closed or if continuous lubrication is provided, the cost of wear of the parts can be reduced.



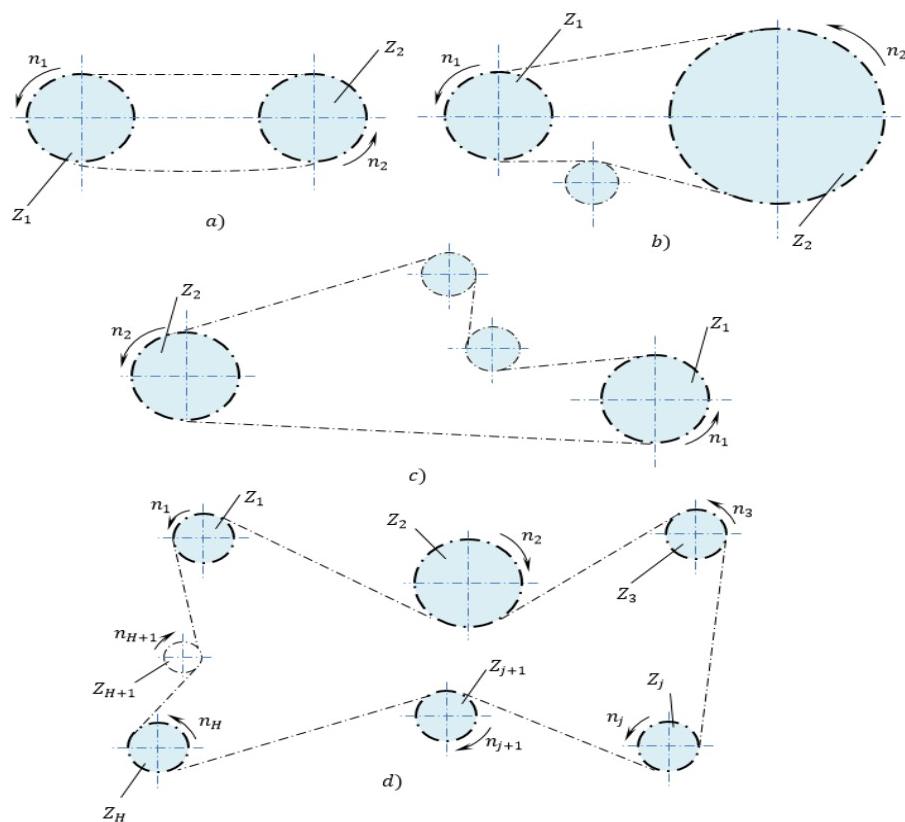


**Figure 3. Chain drive lubrication methods**

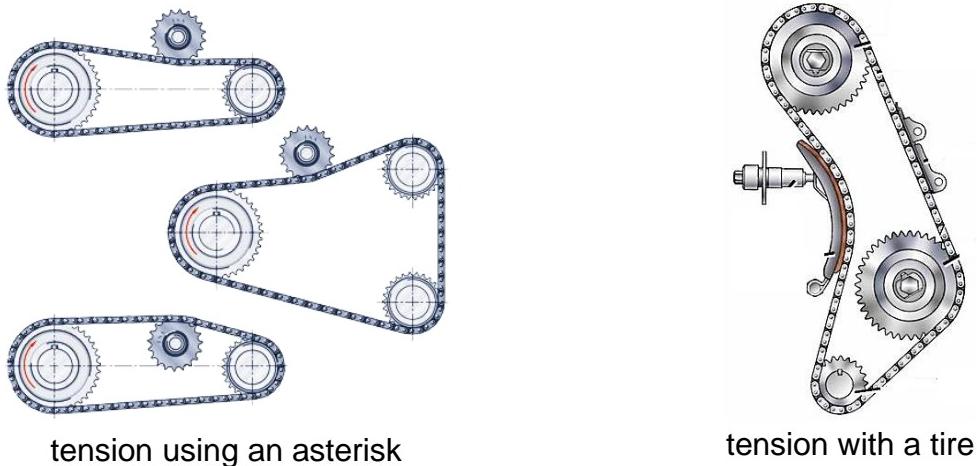
According to the number of transmission shafts, there are two-shaft and multi-shaft types of chain drives (Fig. 4). The reliable transmission of movement to several shafts at the same time is one of the unique advantages of the chain drive.

A chain transmission causes an increase in cooling during operation, a decrease in transmission reliability and technological indicators. An increase in cooling causes rapid erosion of the profiles of the transmission chain links and

sprocket teeth, and a sharp increase in the longitudinal and transverse vibrations of the cooling network. Any chain drive has a minimum coolness value, and it's important to keep it consistent. Tensioning is done by moving one of the shafts, moving the tensioning sprocket or roller axis, and using the tensioning tire. Tensioning using tensioning devices is carried out periodically or with automatic tensioning sprockets, rollers or tires (Fig. 5).



**Figure 4. Schemes of two-shaft (a and b) and multi-shaft (c and d) chain drives**



**Figure 5. Tensioning tools**

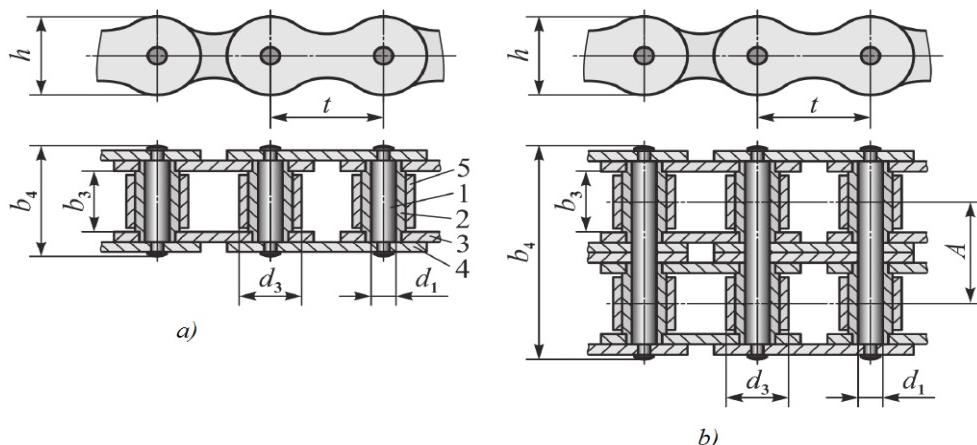
Bushing, roller and toothed types of chain drives are widely used in the operation of technological machines. Bushing and roller chains are standardized by GOST 13568-97 and silent chains by GOST 13552-81 [5-6.]

In the design of chain transmissions, the main geometric parameter is the chain pitch  $t$ , (mm) and is equal to the distance between the pivot axes. Also destructive loading according to the nature of the main force  $F_p$ , kN is considered.

It is recommended to use a roller chain drive in the mechanical drive of the seed distribution device. Let's analyze the specific structural aspects of roller chains that transmit motion in accordance with the system of our research. Today, PR, 2PR, 3PR, 4PR types of chain transmissions

used in technological machines are widely used [7].

Figure 1.6 shows the single-line PR (Figure 6, a) and two-line 2PR (Figure 6, b) designs of the bushing roller chain that transmits motion. The structure consists of a roller 1, bushing 2, inner 3 and outer 4 plates and a freely moving roller 5 in bushing 2. Bushing roller chains are distinguished from bushing chains by a roller. The friction created in the working profiles of the bushing chain and sprocket reduces the working resource of the transmission, i.e. the service life. It is the rolling movement of the roller on the surface of the bushing and the formation of a high kinematic pair with the sprocket teeth that provides an opportunity to increase the service life of the transmission [8].



**Figure 6. Construction of the drive bush roller chain: a) one-line; b) two-line**

The main standard parameters of one- and two-row roller chain transmissions, which are widely used in technological machines, especially in oil production enterprises, are presented in Tables 1 and 2 below. From the tables below according to the value of transmitted power. Silent chains are distinguished by smooth and quieter operation compared to roller chains. Silent chains appeared in 1895 and began to be widely used in

technological machines [9]. Their links consist of rows of tooth-shaped plates connected in a certain sequence with rollers. The ability of silent chains to work at high speeds is the basis for their wide use in technological machinery. Silent chains are developed in accordance with GOST 13552-81 in two types: PZ-1 with one-way coupling and PZ-2 with two-way coupling.]

**Table 1.1**  
**The main parameters of the single-line drive chain**

Designation	t	$b_3$	$d_1$	$d_3$	h	$b_4$	$F_p, kN$	1 meter chain mass kg
ПР-19,05-31,8	19,05	12,70	5,94	11,91	18,2	33	31,8	1,9
ПР-25,4-60	25,4	15,88	7,92	15,88	24,2	39	60,0	2,6
ПР-31,75-89	31,75	19,05	9,53	19,05	30,2	46	89,0	3,8
ПР-38,1-127	38,1	25,40	11,10	22,23	36,2	58	127,0	5,5
ПР-44,45-172,4	44,45	25,40	12,70	25,40	42,4	62	172,4	7,5
ПР-50,8-227	50,8	31,75	14,27	28,58	48,3	72	227,0	9,7
ПР-63,5-354	63,5	38,10	19,84	39,68	60,4	89	354,0	16,0

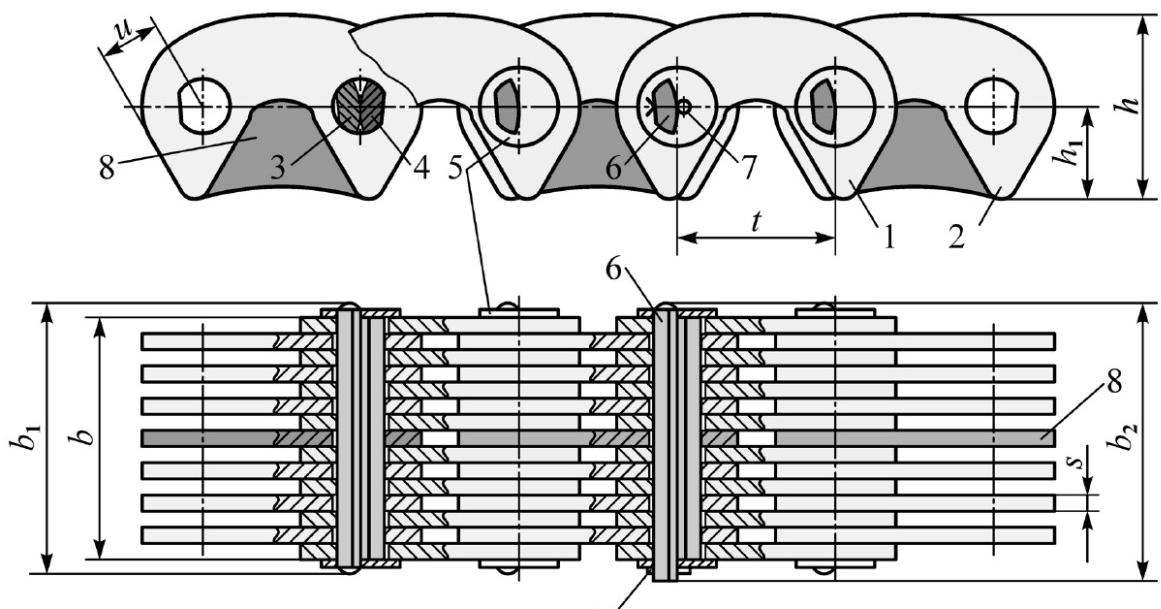
**Table 1.2**  
**The main parameters of the two-line drive chain**

Designation	t	$b_3$	$d_1$	$d_3$	A	h	$b_4$	$F_p, kN$	1 meter chain mass kg
2ПР-19,05-64	19,05	12,7	5,96	11,91	22,78	18,08	53,04	64,0	2,9
2ПР-25,4-114	25,4	15,88	7,92	15,88	29,29	24,2	68	114,0	5,0
2ПР-31,75-177	31,75	19,05	9,53	19,05	35,76	30,2	82	117,0	7,3
2ПР-38,1-254	38,1	25,4	11,10	22,23	45,44	36,2	104	254,0	11,0
2ПР-44,45-344,8	44,45	25,4	12,70	25,40	48,87	42,24	110	344,8	14,4
2ПР-50,8-453,6	50,8	31,75	14,27	28,58	58,55	48,3	130	453,6	19,1

PZ-1 type gear chains with one-way coupling are connected to the sprocket only through the inner side. Silent chains are connected in series and consist of outer 1 and inner 2 plates with a special hole opened for the support roller (Fig. 7).

Modern silent chains are made with a special hinge [10]. The rolling joint consists of two prisms 3 and 4, which are in contact with each other on a cylindrical surface. Prism 3 is pressed into plate 1 and prism 4 is pressed into plate 2 analogously. The

length of the prism 3 is correspondingly equal to the width of the outer link b. The length of the prism 4 is longer and the puck 6 is inserted into the neck at its end and the end is riveted. One end of the elongated prism is riveted to connect the ends of 6 chains. A stopper consisting of washer 5 and splint 7 is installed on the other end of the extended prism 6. A guide plate 8 is installed in order to prevent the chain from coming out of the sprocket laterally.



**Figure 7. Gear chain drive construction**

**Development of efficient constructions of chain drives for drum feeder.** Based on the results of the research carried out at the vegetable oil production enterprise, it can be noted that chain transmissions are used in most technological machinery. At the same time, the management structure of the enterprise's technological devices is formed in a way that does not correspond to the nature of the technological load. In the course of our research, a number of proposals were developed for improving the drum that distributes the required amount of seed to the linter. In order to evenly distribute the seed in the bunker and reduce the impact of the forces that damage the seed, three types of chain drive constructions were developed for the seed distribution drum.

Today, most chain drives introduced in technological machines are used in the open state. The conducted studies have shown that it is necessary to take into account the dusty environment rich in seed debris in vegetable oil production enterprises, and there is an opportunity to optimize the composition of technological machines. First of all, equipping the chain drives with a protective case can increase

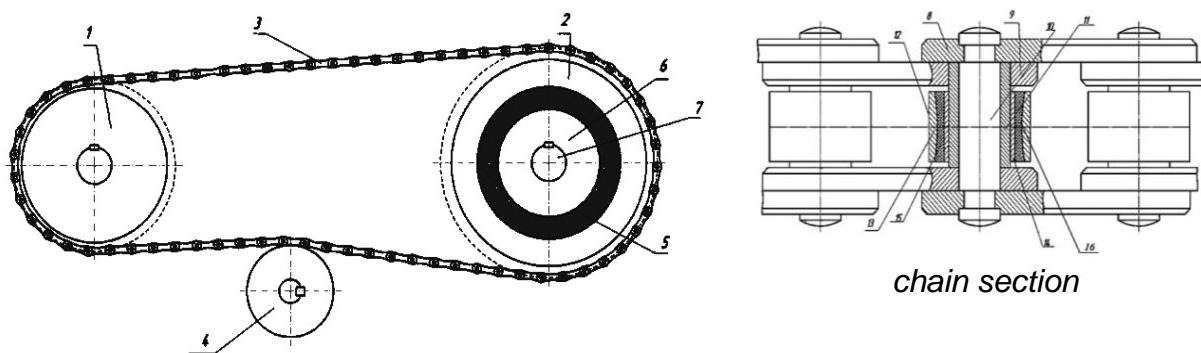
the service life and safety of the transmission. In turn, there is an opportunity to significantly reduce the level of noise coming from the transmission. In the course of the research, an effective chain drive structure was developed that is flexible to the loads on the working bodies of technological machines. One of the main disadvantages of the existing constructions used today in technological machines is the small angle of coverage of the sprocket teeth of the chain and the increase of the cooling of the driving network. As a result, we can observe that transmission efficiency decreases and noise is significantly generated. The load on the transmission and the increase in speed lead to an increase in impact forces acting on the chain roller from the sprocket teeth.

#### **Chain drive with rubber element.**

The results of the conducted research show that the main reason for the increase in the complex dynamic loading of the chain transmission was the impact of the impact forces during the engagement of the sprocket and the chain. In order to reduce this negative effect, structures with increased kinematic and dynamic capabilities were developed. The proposed chain drive structure consists of a driving

and driven sprocket, a tension roller and a chain. The drive chain consists of an inner and outer plate, a roller, a bushing and a roller. The bearing roller consists of inner and outer bushings and a rubber element (rubber) located between them. The drive sprocket is made of composite material, and a rubber element is placed between the sprocket disk. The above-mentioned design is resource-saving and significantly reduces noise. As shown in Figure 8, the roller, which is recommended to be composed, has an outer bush with a bubble inside. Having the roller structure in this form reduces friction, somewhat dampens the effect of impact forces with the sprocket teeth, and creates a basis for reducing noise during operation. The extension structure consists of a driving sprocket 1, a driving sprocket 2 and a chain covering them 3, a tension roller 4. The drive is made in the form of a sprocket, and the outer part consists of a toothed flange 2, a base 6, an output shaft 7 and a rubber bushing 5. Chain 3 consists of inner 9 and outer 8 plates, roller 10, bushing 11 and roller 12 containing inner 13 and outer 14 bushings and a rubber element (rubber) 15 located between them. The strap element 15 has a concave outer surface 16 and is made to fit the inner side of the outer bushing 8 [11.]

The proposed chain transmission works in the following order: the drive from the driving sprocket 1 to the driven sprocket 2 is transmitted through the chain 3. Then, the drive sprocket 2 is transmitted to the output shaft 7 through the rubber bushing 5 and base 6. It is observed that the frictional force and other harmful forces generated between the chain 3 and the sprocket 2 are somewhat reduced when passing through the rubber element 5. When the chain 3 interacts with the guide 1 and the guide 2 sprockets, the wear of the bushing 13 and the inner 1 and outer 2 sprockets is reduced due to the deformation of the rubber element 15 in the chain roller 12. Due to the deformation of the rubber element 15, the friction between the bushing 11 and the roller 10 also decreases. This leads to an increase in the service life of the transmission elements. During operation, it is recommended that the surface 16 of the rubber bushing 15 be concave in order to center the pressure forces acting on the roller 12 from the driving 1 and driven 2 sprockets. The rubber element in the roller 12 stabilizes the external pressure forces. This will increase the service life of the chain.



**Figure 8. Chain transmission scheme with a rubber element**

**Chain drive with integrated centering roller.** The selection of geometric parameters of chain transmissions in accordance with technological loads, at the same time,

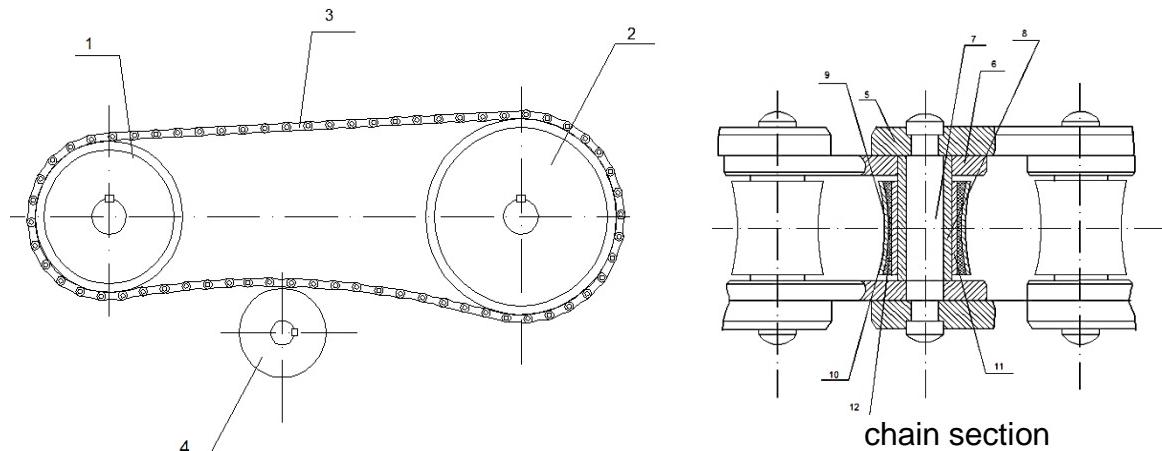
creation of self-efficient constructions of details and improvement of existing constructions were carried out.

It was observed that the chain transmissions used in vegetable oil

production machines, during their operation, the longitudinal and transverse vibration movement of the chain accelerates the value of wear in the sprocket teeth and chain kinematic joints. The proposed drive structure consists of driving 1 and driven 2 sprockets and their covering chain 3, tensioning device 4. The chain 3 consists of outer 5 and inner 6 plates, a roller 7, a bushing 8 and a content roller 9 [12]. The chain roller has a composite construction. The bearing roller 9 consists of outer 10 and inner 11 bushings, and a rubber element 12 located between them. The rubber bushing 12 has a convex appearance corresponding to the outer surface 13 and a concave

appearance corresponding to the inner side of the outer bushing 10 (Fig. 9).

In the proposed chain transmission, the rotary motion is transmitted from the driving sprocket 1 to the driven sprocket 2 through chain 3. When the roller 9 containing the teeth of the guide 1 and the guide sprocket 2 is in contact with the roller 9, due to the deformation of the rubber element 12, the wear of the bushing 10 and the teeth of the leader 1 and the guide sprocket 2 is reduced. In addition, the amount of friction forces between the bushing 8 and the roller 7 is reduced. This ensures that the chain transmission increases its service life and ensures smooth operation.



**Figure 9. Chain drive with integrated centering roller**

During operation, it is recommended that the edge of the bushing 9 has the feature of centering the external pressure so that the bushing 9 performs the necessary deformation when the outer surface 13 of the rubber bushing 12 is in contact with the sprockets 1 and 2. This construction reduces the level of noise and increases the service life of the transmission.

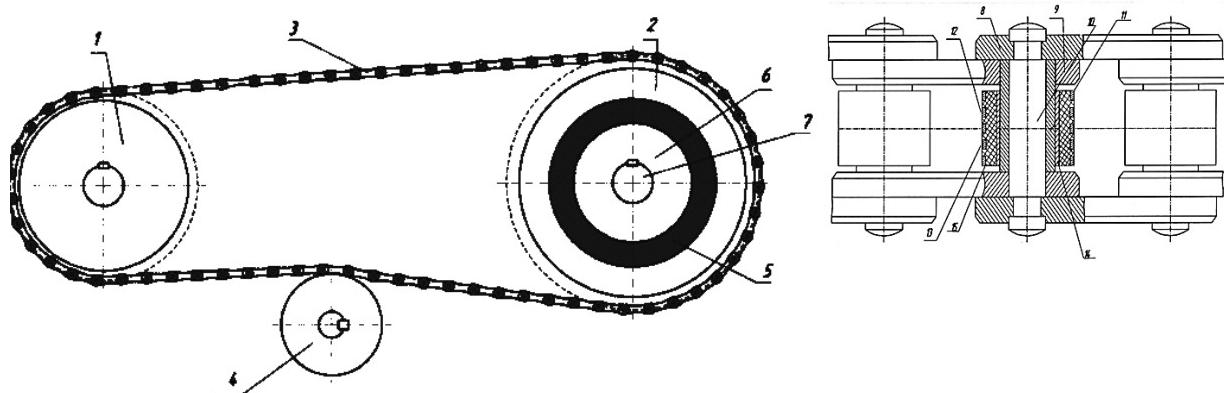
**Chain drive with rubber element with ring composition.** In cases where the movement of the chain is less than 1m/sec, a number of research studies were conducted to reduce the geometric parameters and noise value of the roller structure of the bushing roller chain transmission to the minimum level. Based

on the results of the research, the construction of the roller chain transmission with a ring structure was proposed.

Today, increasing the resource efficiency of chain transmissions requires the development of structures that provide an opportunity to dampen harmful forces. The proposed transmission structure consists of driving 1 and driven 2 sprockets, an endless chain 3 covering them, and a timing device 4. It is recommended that the drive sprocket is 2-component, consisting of a toothed ring 2, a base 6 and an output shaft 7, a bushing with a belt ring 5. Chain 3 includes outer 8 and inner 9 plates, roller 10, bushing 11 and content roller 12. The component roller

consists of an outer ring bushing 13 and an inner bushing 14 and a rubber bushing 15 located between them [13]. It is

recommended to have a metal ring on the outer surface of the rubber bushing 15 (Fig. 10).



**Figure 10. Chain transmission scheme with rubber element with ring composition**

This chain drive works in the following order. The rotary motion is transmitted from the driving sprocket 1 to the driven sprocket 2 through chain 3. During the movement, the movement from the driven sprocket 2 is transmitted to the output shaft 7 with the base 6 through the rubber element 5. When the driving sprocket 2 turns to a certain angle, the friction, wear and damaging forces generated between the chain 3 and the driving sprocket 2 are amortized in the rubber bushing 5. As a result, the movement of the output shaft 7 is smooth and noiseless. Sufficient deformation of the rubber element 15 as a result of the action of the extension driving 1 and the driven 2 sprockets with the content roller 12 of the chain 3 prevents the wear of the ring bushing 13 and the driving 1 and the driven sprockets 2. In addition, there is also a

decrease in friction forces between the roller 10 and the bushing 11 of the chain 3. The rubber bushing of the roller 12 of the chain 3 has the property of damping the unevenness of the movement from the energy source and the technological resistance. This increases the working resource and reduces the noise.

**Summary.** According to the results of the conducted research, resource-efficient and effective new chain transmission designs with wide kinematic and operational possibilities were recommended for driving the seed drum: a chain transmission with a combing roller with a rubber element; transmission with a chain with a rubber element; a construction of transmissions with a roller chain with a ring structure was developed.

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UDC 621.892.012

## RESULTS OF A STUDY OF THE INFLUENCE OF OIL CONTAMINATION ON WEAR OF THE WORKING SURFACE OF DIESEL CYLINDER LINES

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### Abstract:

**Objective:** to study the influence of changes in the operational properties of oils and to monitor worn cylinder liners of D-243 diesel engines and transport tractors in order to determine the influence of the lubricating properties of motor oils on the wear of the working surface of cylinder liners.

**Methods:** during the research, the laws of the theory of lubrication, wear friction, as well as methods based on existing regulatory documents were used.

**Results.** When the engine is running, the oil, together with the contaminants in it, enters the annular grooves of the piston. This mixture, being in the piston grooves in the form of a thin film, at high temperatures, as a result of subsequent oxidative processes, forms viscous asphalt-resin deposits, which reduce the gaps in the grooves and, acting like slot filters, begin to retain contaminants. When operating diesel engines, cylinder liners are exposed to high temperature and pressure, as a result of which microroughness appears on the working surface under the influence of tribomechanical and tribotechnical influences. To determine the amount of wear on the working surface of engine cylinder liners, linear and weight methods, as well as the micrometer method, are widely used.

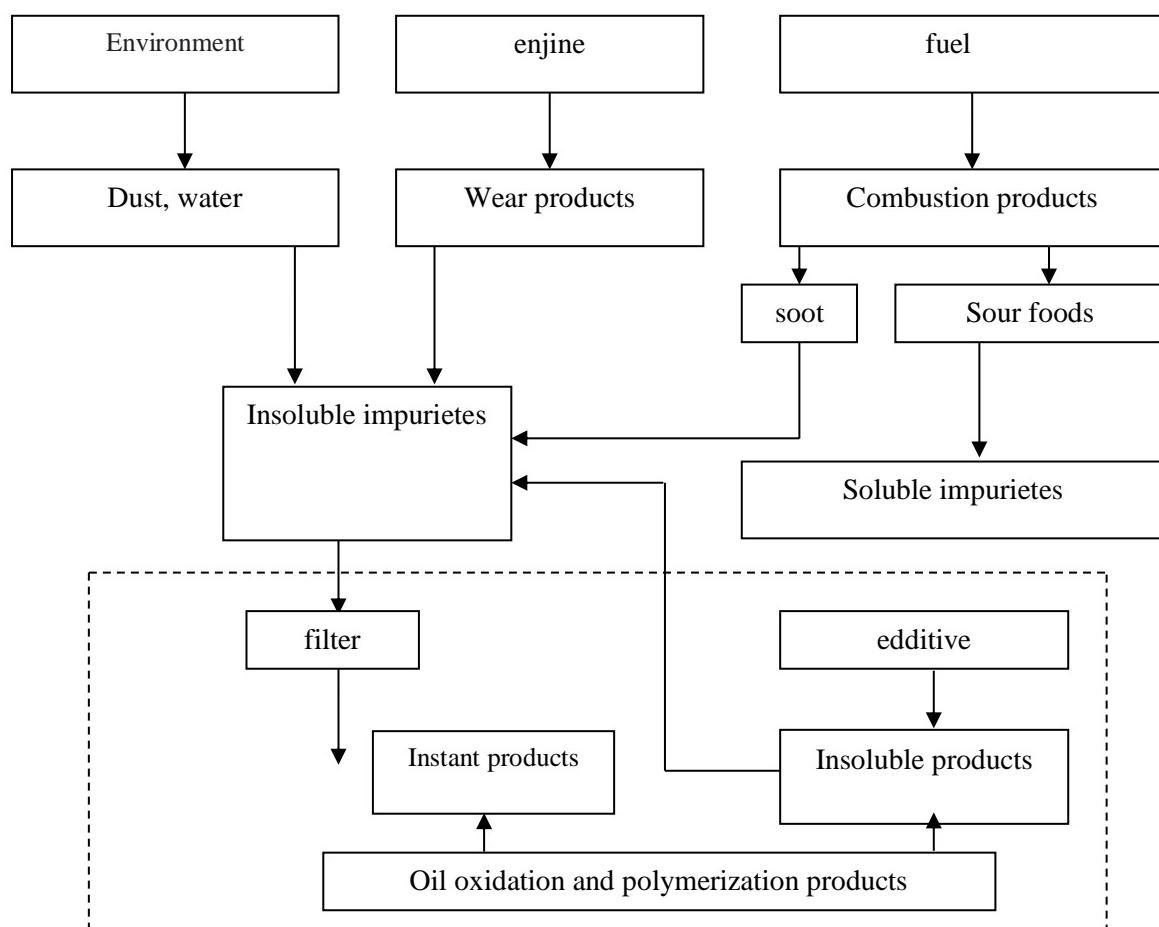
**Conclusion.** Experience has shown that contaminants in motor oil consist of particles with a metal base and particles of organic compounds - varnish, similar in structure to graphite. When using diesel fuel with optimal concentrations, less varnish was formed, because wear is reduced to a lesser extent. During engine operation, as a result of natural wear of the liner, the uneven operation of the cylinders increases, performance characteristics decrease, and technical and operational indicators deteriorate. When operating diesel engines, cylinder liners are exposed to high temperature and pressure, as a result of which microroughness appears on the working surface under the influence of tribomechanical and tribotechnical influences. Micrometering of the liner must be carried out in different planes and sections, at least 10, which requires a long time.

**Keywords:** liner, diesel, pollution, concentration, oil, micrometer, motor.

**Introduction.** As a result of the release of film decomposition products into the engine crankcase, the oil in the circulation circuit becomes contaminated, varnish is deposited on engine parts, the drainage holes of the oil scraper rings are clogged, the drainage holes in the piston are blocked, and filter contamination increases.

**Methods.** When the engine is running, the oil, together with the

contaminants in it, enters the annular grooves of the piston. This mixture, being in the piston grooves in the form of a thin film, at high temperatures, as a result of subsequent oxidative processes, forms viscous asphalt-resin deposits, which reduce the gaps in the grooves and, acting like slot filters, begin to retain contaminants [1-7].



**Fig.1. Oil contamination pattern**

The general concept of oil contamination refers to the accumulation of undesirable impurities in the oil that reduce the performance properties of the oil. Contaminants entering oil can be divided into soluble and insoluble impurities [11]. Insoluble impurities cause abrasive wear and carbon deposits in the engine, and soluble acidic impurities cause corrosion [11].

Cylinder liners are the most heavily loaded engine parts. They experience stress from gas forces, lateral pressure of the piston and thermal loads.

In forced engines, the thermal load on the oil films in the cylinder group increases significantly. With increasing loads on the crank mechanism, the film thickness decreases, the relative breakthrough of gases at increased speeds increases by almost 60% [1,3,5,7,8]. As a result, mechanical and thermal destruction of the film occurs, accompanied by deep chemical transformations. Under these severe conditions, the oil film must provide the necessary anti-wear and extreme pressure properties, and not release decomposition products on the surfaces of the piston group parts [1-8].

Thus, a large amount of carbon deposits can accumulate in the radial clearance between the ring and the piston groove. If this gap is filled significantly, the rings will "sit" on the carbon deposits and protrude above the piston surface. In this case, the pressure of the ring on the cylinder increases sharply, which can lead to scuffing of the ring and cylinder.

Thus, rubbing and scuffing of cylinders in engines usually occurs when the ring protrudes by 0.3 and 0.5 mm, respectively.

In addition, if this gap is completely filled with carbon deposits and its hardness increases, when the engine switches to a forced mode, when, due to contagious thermal expansion, the piston diameter increases by a greater amount than the cylinder diameter, the pressure of the ring on the cylinder will sharply increase and

scuffing may occur. surfaces or jamming of the piston in the cylinder.

When analyzing the conditions under which the oil film is located on the surface of the cylinder-piston group, it is necessary to keep in mind the strong dependence of its oxidation on temperature.

The formation of carbon deposits on the piston surfaces makes it difficult to remove heat and contributes to overheating of the piston. Deposits formed in the grooves of the piston rings cause their jamming, loss of tightness of the above-piston space and, consequently, increased breakthrough of gases, which accelerates the processes of tarring and contamination of the oil film. This is accompanied by an increase in oil consumption, a drop in power, overheating of parts, increased wear and scuffing, especially in the piston group [1-8].

The density and composition of carbon deposits largely determine its abrasive properties. The density of soot is significantly influenced by the degree of oxidation of fuel and oil hydrocarbons, as well as the presence of sulfur compounds in the fuel.

According to Breze and Wilson, an increase in sulfur in diesel fuel from 0.08 to 1.5% increases its content in carbon deposits from 1 to 9%, and their relative density increases in this case from 0.08 to 0.5 g/cm<sup>3</sup>. Therefore, the operation of engines on sulfur-containing fuels can contribute to abrasive wear of parts [11-20].

During engine operation, as a result of natural wear of the liner, the uneven operation of the cylinders increases, performance characteristics decrease, and technical and operational indicators deteriorate. When operating diesel engines and gas diesel engines, cylinder liners are exposed to high temperature and pressure, as a result of which microroughness appears on the working surface under the influence of tribomechanical and tribological influences.

To determine the amount of wear on the working surface of engine cylinder

liners, linear and weight methods, as well as the micrometer method, are widely used. Micrometering of the liner must be carried out in different planes and sections, at least 10, which requires a long time. In addition, due to the difference in the temperature of the cylinder liner during measurements, as well as possible differences in the temperatures of the tool and the part being measured, and the pressure of the measuring tip on the surface during repeated measurements during micrometering, measurement errors may occur.

Micrometering of cylinder liners of diesel engines and gas-diesel engines of tractor engines is considered promising for assessing large amounts of surface wear.

Analysis of the measurement results of the internal diameters of diesel cylinder liners confirms that the maximum maximum deviations of dimensions vary from 0.02 to 0.62 mm, the range of scatter of ovality values is within 0.02÷0.20 mm, and taper - 0. 02÷ 0.55 mm [1].

Micrometering of the liner must be carried out in different planes and sections, at least 10, which requires a long time.

In addition, due to the difference in the temperature of the cylinder liner during measurements, as well as possible differences in the temperatures of the tool and the part being measured, and the pressure of the measuring tip on the surface during repeated measurements during micrometering, measurement errors may occur. Micrometering of cylinder liners of diesel and gas-diesel engines is considered promising for assessing large amounts of surface wear [1-5].

**Results.** When the engine is running, the oil, together with the contaminants in it, enters the annular grooves of the piston.

This mixture, being in the piston grooves in the form of a thin film, at high temperatures, as a result of subsequent oxidative processes, forms viscous asphalt-resin deposits, which reduce the gaps in the grooves and, acting like slot filters, begin to retain contaminants [11].

Table 1

### Physico-chemical indicators of used diesel engine oils

Indicators	Try- 1	Try -1				
Kinematic viscosity, at 100 °C,sSt	9,6	8,5	8,8	8,7	8,3	8,8
Density at 20°C, kg/cm <sup>3</sup> no more	0,792	0,795	0,798	0,853	0,796	0,794
Pour point, - °C, not higher	- 16	- 15	- 15	- 15	- 15	- 15
Flash point, °C	201	198	196	194	194	193
Water content, % footprints	0,16	0,19	0,20	0,22	0,22	0,22
Content of mechanical impurities, %	0,041	0,042	0,044	0,046	0,044	0,047
Base number, mg KOH/g	1,96	1,98	1,94	1,96	1,94	1,89
Ash content, no more %	0,83	1,84	0,85	0,84	0,83	0,83

Wear details of the cylinder-piston group depend on acceleration and load modes. Thus, the average wear rate at idle speed is 6.2...9.9 times less than at maximum load. At the maximum speed mode and load, the concentration of iron

(Fe) in the composition of engine oil running on standard fuel increased from  $1.1 \cdot 10^{-4}$  to  $7.8 \cdot 10^{-4}$  g/hour, which is 8-12% more, than when working on conventional fuel.

When operating diesel engines, cylinder liners are exposed to high temperature and pressure, as a result of which microroughness appears on the working surface under the influence of tribomechanical and tribotechnical influences.

To determine the amount of wear on the working surface of engine cylinder liners, linear and weight methods, as well as the micrometer method, are widely used.

Wear of the cylinder liner occurs in its working surface. As a result of wear, the diameter of the working surface increases and the shape of the surface is disrupted.

The wear process of the working surface of the cylinder liner is affected by organic contaminants and abrasive particles in the oil. Liner wear also depends on engine operating hours.

**Discussion.** The inner surface of the sleeve loses its taper along its length and its ovality along its circumference.

The amount of wear is greater than the upper part of the liner due to greater contact with the upper compression rings. When the fuel in the upper part of the cartridge burns, the temperature and pressure of the gases increases.

Combustible gases penetrating under the piston rings contribute to an increase in ring pressure on the working surface of the liner. Under the influence of high temperatures, the oil film flares up and lubrication of the upper part of the liner deteriorates. In addition, the fuel mixture partially washes away the oil layer.

When fuel burns, gases containing carbon oxides and sulfur compounds are formed. These products are influenced by water vapor, which contribute to the formation of sulfate and carbonic acid,

which lead to corrosive wear of the working surface of the cylinder liner.

**Conclusions.** Experience has shown that contaminants in motor oil consist of particles with a metal base and particles of organic compounds - varnish, similar in structure to graphite.

When using diesel fuel with optimal concentrations, less varnish was formed, because wear is reduced to a lesser extent.

During engine operation, as a result of natural wear of the liner, the uneven operation of the cylinders increases, performance characteristics decrease, and technical and operational indicators deteriorate. When operating diesel engines, cylinder liners are exposed to high temperature and pressure, as a result of which microroughness appears on the working surface under the influence of tribomechanical and tribotechnical influences.

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UDC 665.5

## SEPARATION OF THE POLYMER MASS FROM THE WASTE OF THE ALKALINE CLEANING PROCESS OF PYROGAS BY THE EXTRACTION METHOD

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### Abstract:

**Objective.** Pyrogas treatment waste segregation and consists in choosing a selective extractant to extract the polymer mass from the hydrocarbon content.

**Methods.** Segregation of waste, determining the solubility of hydrocarbon content in various solvents and methods such as choosing the most optimal selective extractant for extraction were used.

**Results.** The waste is separated into two layers when it is cooled. 1 - the upper layer (light layer) is determined to be "hydrocarbon content" and 2 - the lower layer (heavy layer) is "alkaline water". Paraffin hydrocarbons have been proven to be the best extractants for separating polymer mass from hydrocarbon content. The molecular mass and density of paraffin hydrocarbons have been found to have an inversely proportional effect on the separation rate of extract and raffinate during the extraction of hydrocarbon content.

**Conclusion.** It was found that the most effective method of separating hydrocarbon content and alkaline water from the waste is the leaching method, and the time of leaching is 240 minutes. Paraffin hydrocarbons were selected as an extractant for the extraction of polymer mass from hydrocarbon content.

**Keywords:** polymer mass, hydrocarbon content, yellow oil, solvent, extraction, organic extractant, alkaline water, selective extractant, raffinate, extract.

**Introduction.** Among hydrocarbons, ethylene and propylene monomers are important organic chemical raw materials, the demand for which is increasing every year. The traditional method of producing ethylene and propylene is pyrolysis of hydrocarbon raw materials (ethane, propane, propane-butane fraction, gas condensate and naphtha). In order to obtain target products for the polymerization process or to process certain unreacted materials, the pyrogas coming out of the reactor must go through a series of processes: recovery, separation, purification and fractionation. In order to purify the pyrogas from sour gases, it is subjected to the absorption

process. An aqueous solution of sodium hydroxide of different concentrations is used to clean pyrogas to the required level of purity. Aldehydes and ketones are formed in the side reactions of pyrolysis of hydrocarbon raw materials. Aldehydes and ketones are converted into polyaldols due to the mechanism of aldol condensation in an alkaline pyrogas purification column. In addition, during the reaction, some diolefins or other unsaturated hydrocarbons can also generate free radicals due to small amounts of oxygen and metal ions, which form cross-linking polymers. Together with polyaldols, these are called "Yellow oil" [1-5].

Problems such as the mechanism of this waste formation and its effect on the system [6-8], suppression of waste generation in the technological process [9-11] have been studied by many scientists. However, no one has yet carried out research on the separation and extraction of hydrocarbon content by refining the waste "Yellow oil".

**Methods.** It is necessary to process the hydrocarbon content in order to make it possible to use it in various branches of the oil and gas-chemical industry. It is known that there are several different methods of separating hydrocarbon mixtures. For example: rectification, absorption, adsorption, separation, crystallization, extraction, etc. The choice of which of the mentioned methods depends on the composition and properties of the raw materials to be separated. Based on its composition and properties, we aimed to

separate the waste "Yellow Oil" by refining it and extracting the obtained hydrocarbon content. In order to achieve the goal set in the work, the tasks of separating the waste "Yellow oil" and determining the solubility of the hydrocarbon content in various solvents, and then choosing the most optimal selective extractant for its extraction, were defined.

Waste, which is considered the object of research, "Yellow oil" is collected in a pocket in the cubic part of the pyrogas purification column and is periodically transferred to a separator. In the separator, "Yellow oil" separated from the gas phase is poured into the drums. It is removed from the device area and is considered a process waste. General information about this waste "Yellow Oil" is presented in table 1, and its properties and composition are presented in table 2.

Table 1

#### General information about waste "Yellow oil"

1. Amount of annual generation of waste	100 t
2. Origin	while cleaning the pie
3. Type of waste	organic
4. Aggregate status	liquid
5. Appearance	oily liquid

Table 2

#### Composition and characteristics of waste "Yellow oil"

1. Density, kg/m <sup>3</sup>	820–830
2. Humidity, %	< 5
3. Composition	Hydrocarbons – 95% Sediments – 5%
4. Solubility	Slightly soluble in water
5. Risk class	3
6. Degree of danger of burning	Flash point +170 °C Auto-ignition temperature +334 °C

When the waste "Yellow oil" is removed from the technological device, a part is mixed with the used alkali and comes out in the form of a suspension. One of the most optimal, cheap and effective ways to separate such mixtures is the method of separation. In this case, the

components of the mixture are separated into two or more layers due to their own weight and density difference.

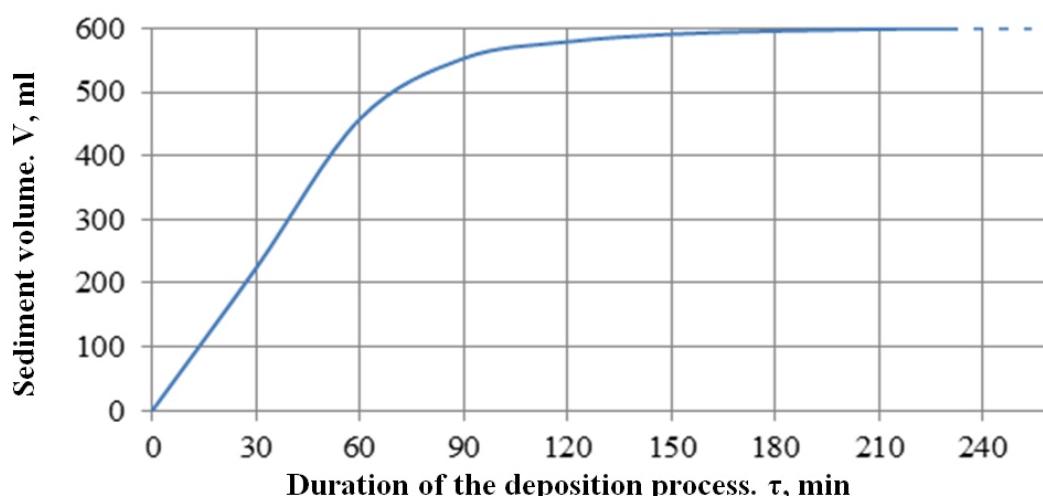
**Separation of waste "Yellow oil" by quenching.** Waste "Yellow Oil" was poured into a 1 liter measuring cylinder up to the 1000 ml mark and timed to determine

the pause time. The amount of precipitated substance was measured every 30 minutes. The experiment was continued until the precipitate was separated. 3 experiments were conducted in parallel. Arithmetic average values of precipitation amounts obtained every 30 minutes in all three experiments were calculated.

As a result of the research, it was observed that the waste "Yellow oil" separated into two layers, and these layers were named based on their composition. 1 - the upper layer (light layer) is called "**hydrocarbon composition**" because it contains a mixture of hydrocarbons. 2 - the bottom layer (heavy layer) this layer is

called "**alkaline water**" because it exhibits a high alkaline property, which is a solution of used alkali and salts in water. The results obtained in the experiment were depicted in the graphic form presented in figure 1.

Since the hydrocarbon content consists of hydrocarbons, organic polar and non-polar extractants were chosen as extractants. For each class of organic extractants, substances that were liquid under standard conditions were obtained. Paraffins - hexane, naphthenes - cyclohexane, arenes - benzene, alcohols - ethanol and organic acids - ethanoic acid were used as extractants.



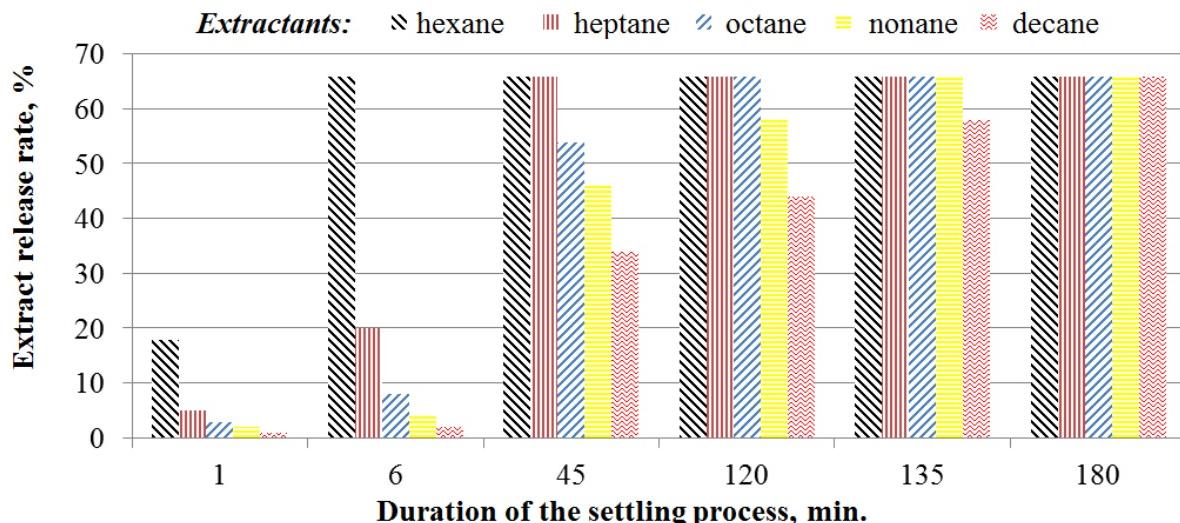
**Figure 1. A graph of the time dependence of the separation of waste "Yellow oil"**

**Determination of the solubility of hydrocarbon content in various organic extractants.** For this purpose, 5 glass test tubes were taken, 2.5 ml of hydrocarbon contents were put into them, and 5 ml of extractants were added to each of them and thoroughly mixed in a vibratory mixer, and then everything was left in a quiet state for a certain time. Paraffin hydrocarbons were selected as the best extractants based on the research results.

**Selection of the optimal selective extractant for the extraction of**

**hydrocarbon content.** This experiment was conducted to determine the fastest extractant that separates raffinate from paraffinic hydrocarbons. For this, hexane, heptane, octane, nonane and decane were selected as extractants from paraffin hydrocarbons (Fig. 2).

The results of an experiment to choose the most optimal selective extractant for the extraction of hydrocarbon content are presented in figure 2.



**Figure 2. Time dependence of extract and raffinate separation during extraction of hydrocarbon content with paraffin hydrocarbons**

Five 100-ml measuring cylinders were taken, and an equal amount of 25 ml of the hydrocarbon content was added to each container after mixing well. 25 ml of extractants were simultaneously poured over the sample in each container: hexane to the first, heptane to the second, octane to the third, nonane to the fourth, and decane to the fifth, and the mouth of the container was closed with a rubber stopper. Five samples were mixed simultaneously using a vibratory mixer. It was then placed at rest and the stopwatch start button was pressed. The volumes of the solid part collected under the five cylinders were determined.

**Results.** The results of the research conducted in order to determine the time of

separation of the waste "Yellow oil" are depicted in the graphic view in fig. 1. In the study, the duration of waste separation was 210-240 minutes, and during this time, the mixture was separated 100%. From the graph shown in Figure 1, it can be seen that 90-95% of the alkaline water is separated in 90-120 minutes, and the remaining 5-10% is separated in 120-240 minutes.

When the waste "Yellow oil" was filtered and separated, it was found that its hydrocarbon content (mass %) is on average 40%, and alkaline water is on average 60%.

Our next research is to determine the solubility of hydrocarbon content in various organic extractants, and the results of the research are presented in table 3.

Table 3

#### Solubility of hydrocarbon content in various organic extractants

No	Extractive	Solubility state
1.	Paraffins	Part of it melted, a suspension appeared, and a precipitate separated (a pale yellow porcelain solution on a yellow precipitate).
2.	Naphthenes	Completely dissolved and mixed (brownish clear solution)
3.	Arenes	Completely dissolved and mixed (brownish clear solution)
4.	Alcohols	Completely dissolved and mixed (yellowish pure solution)
5.	Organic acids	It didn't melt and didn't mix at all

In this case, the state of solubility of hydrocarbon content in organic extractants was classified based on visual appearance

It can be seen from figure 2 that as the molecular weight of paraffin hydrocarbons increases, the rate of separation of raffinate in extraction is observed, the reasons for this are:

- firstly, as the molecular mass of paraffin hydrocarbons increases, their molecular size also increases, and this prevents penetration into the hydrocarbon composition;

- secondly, an increase in the density of the extractant prevents precipitation of the raffinate separated during extraction.

Therefore, it took 6 minutes in hexane, 45 minutes in heptane, 120 minutes in octane, 135 minutes in nonane, and 180 minutes in decane for the complete separation of the raffinate.

Hydrocarbon content was separated into extract and raffinate when extracted using paraffin hydrocarbons (Fig. 3).



a) refined



b) extract

**Figure 3. Appearance of raffinate and extract from hydrocarbon extraction**

Raffinate is a substance insoluble in paraffin hydrocarbons (Fig. 3a). The extract is a mixture of substances dissolved in paraffin hydrocarbons containing hydrocarbon content (Fig. 3b).

The concepts of diffusion coefficient and separation factor are used in the study

of hydrocarbon extraction. The ratio of the equilibrium concentration of the desired component in the extract to the equilibrium concentration of this component in the raffinate is called the diffusion coefficient:

$$m = \frac{y'}{x},$$

here,  $y'$  – the equilibrium fraction of the diffusible component in the extract;  $x$  – equilibrium fraction of the propagating component in the raffinate.

The extraction capacity of the solvent can be determined by the value of the diffusion coefficient. The greater the value

of  $m$ , the higher the ability of such a solvent to extract the desired component from the liquid mixture. In extraction systems, the value of  $m$  varies from 1 to 10000. The following ratio is used to estimate the separation ability of a solvent:

$$\frac{m_1}{m_2} = \frac{y'_1/x_1}{y'_2/x_2} = \frac{y'_1 x_2}{y'_2 x_1} = \frac{y'_1}{y'_2} : \frac{x_1}{x_2} = \beta,$$

here,  $m_1$  – is the diffusion coefficient of the first component in the mixture;  $m_2$  – is the diffusion coefficient of the second component in the mixture.

The quantity  $\beta$  is called the extraction separation coefficient or factor. This coefficient indicates how many times the equilibrium concentrations of the separated components in the extract are greater than the equilibrium concentrations in the raffinate. This coefficient is similar to the relative volatility of the components in the rectification process. In real conditions, the value of  $\beta$  should not be less than 2.

**Conclusions.** It has been found that the most effective method of separating hydrocarbon content and alkaline water from waste is the quench separation

method. In this case, the time of tinib separation was 240 minutes.

The hydrocarbon content was found to be highly soluble in naphthenic hydrocarbons and aromatic hydrocarbons and alcohols. In paraffin hydrocarbons, the hydrocarbon content was observed to split into two. Paraffins have been proven to be the best selective extractants for the separation of polymer mass from hydrocarbon content by extraction method.

It was found that the molecular weight and density of paraffin hydrocarbons have an inversely proportional effect on the rate of separation of extract and raffinate during the extraction of hydrocarbon content. It has been proven that the smaller the mass and density of the extractant, the faster the extraction process.

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## EFFECT OF TEMPERATURE ON PHOTOELECTRIC PARAMETERS OF THREE-WAY ILLUMINATED SOLAR CELLS

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### Abstract:

**Objective.** Increasing the efficiency of solar cells and reducing the amount of material used in its production is one of the important tasks of today.

**Methods.** A 3-way sensitive solar cell was designed for this purpose. Compared with one surface, the efficiency of three surfaces increased by 2,81 times and two surfaces by 1,72 times. One of the main parameters of the environment is temperature. The daily temperature changes according to the seasons. Therefore, it is important to study the effect of temperature on solar elements.

**Results.** In this scientific work, the effect of temperature on the photoelectric parameters of a three-way sensitive silicon-based solar cell was studied. It was found that the temperature coefficients of the photoelectric parameters of the three-way sensitive solar cell do not change when different areas are illuminated.

**Conclusion.** It was determined that the temperature coefficient of the operating voltage is  $2,52 \times 10^{-3}$  V/K, and the temperature coefficient of the filling factor is  $1,8 \times 10^{-3}$  K<sup>-1</sup>. In addition, when the temperature changed from 300K to 350K, the short-circuit current in the three-side light state decreased by 4%.

**Keywords:** Three-way sensitive, solar cell, silicon, modeling, sunlight.

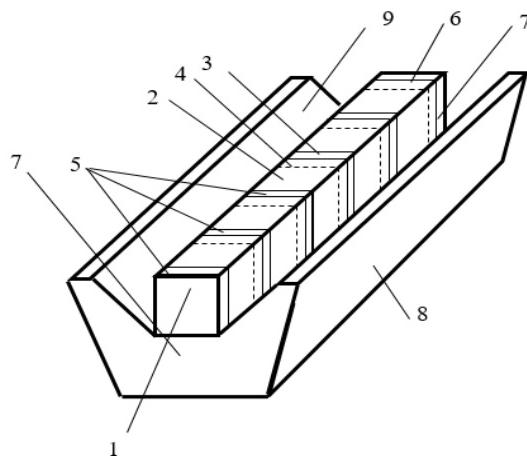
**Introduction.** Along with the increase in the need for energy, the use of renewable energy sources is also increasing. Because renewable energy sources are the best solution to today's energy shortage without harming the environment [1]. According to the International Energy Agency, in 2021 the volume of renewable energy sources reached 276 GW. Among renewable energy sources, solar energy is widely used to obtain heat and electricity [2]. Solar cells are mainly used to convert solar energy into electricity. 85% of solar cells produced in industry are silicon-based solar cells [3]. Therefore, a silicon-based solar cell was chosen as a research object in this scientific work. According to theoretical calculations, the maximum efficiency of a silicon-based solar cell does not exceed 29% [4]. Scientific work is being carried out to increase the efficiency of the

silicon-based solar cell and reduce its cost. For example, in order to reduce the surface recombination and improve the optical properties of a silicon-based solar cell, its surface is covered with SiNx with a thickness of 75 nm or SiO<sub>2</sub> with a thickness of 100 nm [5]. In addition, it has been found that the incorporation of metal nanoparticles into a silicon-based solar cell increases the efficiency [6]. Dual-sensitive silicon-based solar cells have been designed to increase the amount of electricity produced [7]. In the experiment, the efficiency of the front side of the double-sensing silicon-based solar cell was determined to be 19.4% and the back side was 16,5%, but the double-sensing solar cells with the symmetrical efficiency of 18,4% and 18,1% were also made in the experiment [8]. In this scientific work, a new 3-way sensitive silicon-based solar cell is investigated. Because the 3-way sensitive

silicon-based solar cell depicted in Figure 1 is registered as a utility model by the Intellectual Property Agency under the Ministry of Justice of the Republic of Uzbekistan under the number FAP 00623 [9]. But the influence of the environment on its properties has not been studied.

Solar elements are very sensitive to the environment. Therefore, it is important to study the influence of the environment

on their properties. For example, the effect of the angle of incidence of light [10] and temperature on the properties of a nanoparticle incorporated solar cell has been studied [11]. Because mainly the solar elements are affected by the temperature and the angle of incidence of light. Therefore, in this scientific work, the effect of temperature on a 3-way sensitive silicon-based solar cell was studied.



**Figure 1. Project of a 3-way sensitive vertical transition solar element**

2 – n type, 3 – p type, 4 – p-n junction, 5 – contact layer, 6 – top surface, 7 – side surface, 8 – base

**Methods.** There are different ways to study physical processes. These are experiment, theory and simulation. In theoretical studies, it is divided into two, obtaining an analytical solution using the fundamental theory of the process and empirical formulas created according to the values determined in the experiment. The simulation method is considered somewhat more complicated. Because, in the process of simulating devices, the fundamental theory and the empirical formula determined in the experiment are used together. The basis of simulation of semiconductor devices is special differential equations. Eigendifferential equations are difficult to calculate using an analytical method, so numerical methods are used. Because it is possible to algorithmize the calculation sequence through numerical methods and create programs based on this. Primary conditions play an important role in special differential

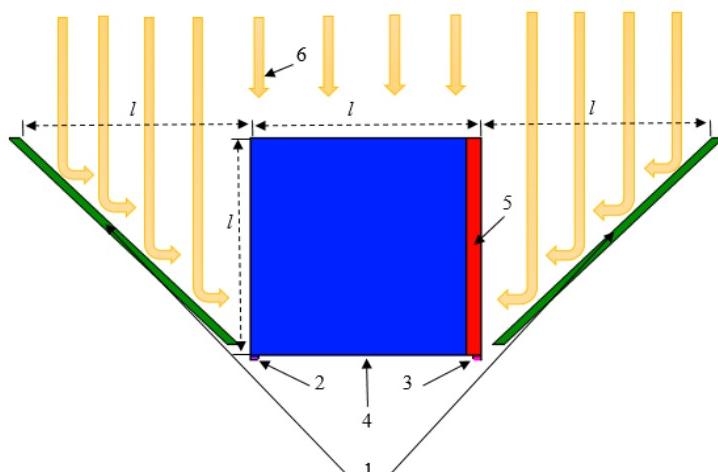
equations. Initial conditions can be in the form of an exact value and a function. Empirical formulas determined in the experiment are mainly used as initial conditions in the modeling of physical processes.

TCAD (Technology Computing Aided Design) programs are widely used in the simulation of semiconductor devices. TCAD is a new family of programs based on CAD programs. CAD programs are mainly designed to create 3D and 2D geometric models of devices. An example of this can be Solidworks or AutoCAD programs. TCAD programs can simulate physical processes in devices by giving them physical properties in addition to creating geometric models of devices. The most common TCAD programs include Sentaurus TCAD, Silvaco TCAD, and Lumerical TCAD. Therefore, the Sentaurus TCAD software package from Synopsys was used in this research.

Sentaurus TCAD is a comprehensive software package that includes 23 instruments. It is enough to use 4 instruments to model the solar elements. These are Sentaurus Structure Editor, Sentaurus Device, Sentaurus Visual and Sentaurus WorkBench. Each instrument has its own function. In Sentaurus Structure Editor, 2D and 3D models of devices are created and meshed for numerical calculations. In Sentaurus Device, physical properties are assigned to the geometric model created in Sentaurus Structure Editor, and electrical, optical, and thermal properties of the device are calculated using numerical methods. In Sentaurus Visual, the results obtained on the Sentaurus Device are graphically displayed and visualized. Sentaurus WorkBench serves as a single environment for the above three instruments to exchange information with each other and manage the virtual experience process.

The simplest solar cell consists mainly of front and rear contacts and a p-n

junction. To simulate solar elements, their geometric model is developed just like their appearance in real life. Only to speed up the calculation process and increase the calculation accuracy, their size is taken smaller. Figure 2 shows the geometric model of the system developed for three-way illumination of a silicon-based solar cell. In order for light to fall on the three surfaces of the solar cell with the same intensity, the reflective silver is placed at an angle of 45° on both sides. Because the light is emitted parallel to the p-n junction. The light falling on the silver reflectors is directed perpendicularly to the two sides of the solar element. The width and length of the solar element are equal to 175  $\mu\text{m}$ . Boron active atoms in the amount of  $10^{15} \text{ cm}^{-3}$  are included in the p field. Phosphorus active atoms in the amount of  $10^{17} \text{ cm}^{-3}$  have been included in n field. The thickness of the n field is 3,5  $\mu\text{m}$  and the thickness of the p field is 171,5  $\mu\text{m}$ . The AM1,5G spectrum was chosen as the light source.



**Figure 2. Geometrical model of the solar cell for 3-way lighting and the overall system made in Sentaurus Structure Editor**

1 - silver reflectors, 2,3 - contacts, 4 - p type, 5 - n type, 6 - light beam and l - length.

**Theory.** The main role in the simulation of semiconductor devices is played by differential equations. For example, to determine the electrical parameters of a simple semiconductor p-n

structure in the equilibrium state, it is enough to calculate the Fermi statistics given in formula 1 and the Poisson equation given in formula 2.

$$n = N_c F_{1/2} \left( \frac{E_{F,n} - E_c}{kT} \right) \text{ and } p = N_V F_{1/2} \left( \frac{E_V - E_{F,p}}{kT} \right) \quad (1)$$

The distribution of the concentration of charge carriers along the semiconductor device is determined with the help of Fermi statistics. It is not possible to calculate the function of Fermi statistics analytically due to the presence of the Fermi half-integral in its composition. The function of Fermi statistics is brought to the Boltzmann approximation by introducing data conditions for calculation in an analytical method. But the Boltzmann distribution gives a more precise value of energy only

$$\Delta\varphi = -\frac{q}{\varepsilon} (p - n + N_D + N_A) \quad (2)$$

Modeling solar cells in semiconductor devices is more complicated. Because, in addition to the electrical and thermal properties of solar cells, optical properties should also be taken into account. Sentaurus Device mainly uses Transfer Matrix Method (TMM), Ray Tracing Method and Beam Propagation Method to determine optical properties of solar cells. Each style has its own advantages. For example, the TMM method calculates the optical properties of thin solar cells taking into account the interference phenomenon. The Ray Tracing method was used to determine the optical properties of the system depicted in Figure 2. Because it is necessary to take into account that the light falling on the solar element and silver reflectors will be refracted and populate them. In the Ray Tracing method, a certain number of light rays are sent to the solar

in a certain range. Since Sentaurus TCAD mainly uses a numerical method, the Fermi function itself was used to calculate the Fermi statistics. Because it is possible to calculate the Fermi function in iterative or numerical methods. The calculated concentration of electrons  $n$  and holes  $p$  is put into the Poisson equation, and the electric field strength and electric potential distribution in the semiconductor device are determined.

cell, and the refracted and reflected parts of each ray are considered as independent rays. When the light intensity is less than the minimum light intensity set during modeling, the calculation of this light is stopped. In turn, the energy of each ray falling on the solar element at the beginning of the simulation is divided into absorbed, released and stopped parts at the end of the simulation. One ray can be divided into more than a thousand rays. A part of these rays can return and pass through the surface of the solar element. This part is considered free rays. It can lose its energy by being absorbed in a solar cell. The remaining part will stop the calculation process before it has enough energy. This part forms the stopped rays. But the total energy of each ray falling on the solar element is equal to the sum of each of them and is calculated based on formula 3.

$$P_{total} = P_{abs} + P_{escape} + P_{stopped} \quad (3)$$

In order to determine the optical properties of the devices, the basic optical parameters such as the refractive index and absorption coefficients of the materials containing the device should be known. In general, the optical parameters of materials are determined by the complex refractive index given in formula 4. The real part of the complex refractive index is the

refractive index of the material, and the abstract part is the "excitation coefficient". The light refraction index and "excitation coefficient" of materials depend on the wavelength of light. But the exact function is not defined for each material. Therefore, in the modeling process, the refraction index and the "excitation coefficient" table of dependence on the wavelength of light,

created according to the experimental results, are used. This ensures the accuracy and reliability of the optical

properties determined by the simulation of the solar cell.

$$n_{tot}(\lambda) = n(\lambda) + ik(\lambda) \quad (4)$$

The absorption coefficient of materials is determined by "excitation coefficient" as given in formula 5.

$$\alpha(\lambda) = \frac{4\pi k}{\lambda} \quad (5)$$

In the Ray Tracing method, certain boundary conditions are included in the calculation of optical properties. Basically, the relationship between the angles of incidence, refraction and return of the light falling on the boundary of two media is determined by Snell's law given in formula 6.

$$\frac{n_1}{n_2} = \frac{\sin(\gamma)}{\sin(\theta)}, \quad \beta = \theta \quad (6)$$

The relationship between the energies of the incident, refracted and reflected rays at the boundary of two media is determined by the Fresnel formulas given in formula 7. When Snell's and Fresnel's laws are used as boundary conditions, the coefficients of reflection of light at the boundary of two media change according to the wavelength of light. Because, as mentioned above, the refractive index and absorption coefficient of materials depend on the wavelength of light. Another possibility of Sentaurus Device is to give the transition or return

coefficients of two media boundaries as fixed numbers. In this scientific work, Fresnel and Snell's laws were used as boundary conditions in the areas of the solar element in contact with the media. Snell's law and constant reflection coefficient  $R=1$  were used as a boundary condition for the silver reflector (Figure 2.) and the air boundary. The purpose of this is to direct the light falling on the silver reflector perpendicular to the two side surfaces of the solar cell without reducing its energy.

$$\left\{ \begin{array}{l} r_t = \frac{n_1 \cos \beta - n_2 \cos \gamma}{n_1 \cos \beta + n_2 \cos \gamma} \\ t_t = \frac{2n_1 \cos \beta}{n_1 \cos \beta + n_2 \cos \gamma} \end{array} \right. \text{ and } \left\{ \begin{array}{l} r_p = \frac{n_1 \cos \gamma - n_2 \cos \beta}{n_1 \cos \gamma + n_2 \cos \beta} \\ t_p = \frac{2n_1 \cos \beta}{n_2 \cos \beta + n_1 \cos \gamma} \end{array} \right. \quad (7)$$

The amount of electrons and holes formed when light is absorbed in the layers of the solar cell was determined by the optical generation formula given in formula 8. Solar cells have not only optical, but also thermal generation, and this is also taken into account in the modeling of this scientific work. In addition, Auger and Shockley-Read-Hall recombination were also taken into account in the modeling,

since the studied solar cell is made of silicon. After that, the total distribution of electrons and holes in the solar cell was calculated using the Fermi function given in formula 1. As written above, the determined concentration of electrons and holes was put into the Poisson equation given in formula 2, and the equation was calculated using a numerical method.

$$G^{opt}(x, y, z, t) = I(x, y, z) [1 - e^{-\alpha L}] \quad (8)$$

To calculate using the numerical method, the solar cell must be meshed. In

this scientific work, the solar element was meshed from 0,01 μm to 0,02 μm on the y

axis from a minimum of 0,04  $\mu\text{m}$  to a maximum of 0,08  $\mu\text{m}$  on the x axis. Two types of grids were created to calculate the

optical and electrical properties of the solar cell. But the size of their nets was made the same.

$$\nabla \cdot \vec{J}_n = qR_{net,n} + q \frac{\partial n}{\partial t} \quad \text{and} \quad -\nabla \vec{J}_p = qR_{net,p} + q \frac{\partial p}{\partial t} \quad (9)$$

When a photon is absorbed in a solar cell, an electron-hole pair is formed, and due to the internal field created by the p-n junction, they are separated. That is, they will act. When the solar cell is illuminated, charge carriers move and current is generated. The change in the concentration of charge carriers in a specific volume of the solar cell over time creates a current. The relationship between the change in the concentration of electrons and holes over time and the current densities they generate is expressed by the continuity equation given in formula 9. Sentaurus Device has 4 main models for calculating the transfer of charge carriers: Drift-Diffusion, Thermodynamic, Hydrodynamic and Monte Carlo. In Sentaurus Device, the Drift-Diffusion model is the usual model for calculating the migration of charge carriers. That is, if a specific model for calculating the migration of charge carriers is declared

in the command file of Sentaurus Device, the program automatically selects the Drift-Diffusion model. In this scientific work, the thermodynamic model given in formula 10 was used to calculate the current density generated by electrons and holes. Because in this model, the effect of temperature on the migration of charge carriers and the phonons generated during the recombination process are also taken into account. However, for this, the temperature equation given in formula 11 should also be calculated. That is, in order to correctly use the Thermodynamic model, it is not enough to declare the Thermodynamic model in the Physics part of the command file of Sentaurus Device, in addition, it is necessary to calculate the Temperature equation in the "Solve" part of the command file. Otherwise, the thermodynamic model gives the same result as the drift-diffusion model.

$$J_n = -nq\mu_n(\nabla F_n + P_n \nabla T) \quad \text{and} \quad J_p = -pq\mu_p(\nabla F_p + P_p \nabla T) \quad (10)$$

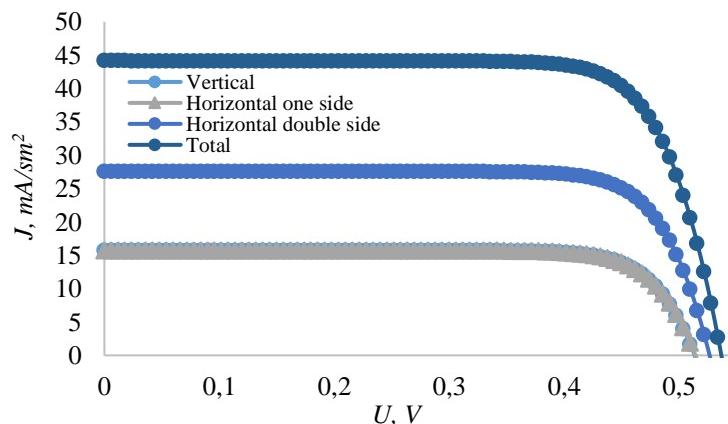
$$\begin{aligned} \frac{\partial}{\partial t}(c_l T) - \nabla(k \nabla T) &= -\nabla[(P_n T + F_n) \vec{J}_n + (P_p T + F_p) \vec{J}_p] - \\ &- \frac{1}{q} \left( E_c + \frac{3}{2} kT \right) (\nabla \vec{J}_n - q R_{net,n}) - \frac{1}{q} \left( E_v + \frac{3}{2} kT \right) (-\nabla \vec{J}_p - q R_{net,p}) + \hbar \omega G^{opt} \end{aligned} \quad (11)$$

Through the above simulation steps, the effect of temperature on the characteristics of a solar cell with three surfaces was determined.

**Results and Discussions.** In this scientific work, the photoelectric parameters of a silicon-based solar cell with a width and thickness of 175  $\mu\text{m}$  were determined in 4 different ways, and the effect of temperature on them was studied. Figure 1 shows the volt-ampere characteristics of a silicon-based solar cell with different areas illuminated. The short-circuit current and operating voltage when

the light is applied vertically, that is, parallel to the p-n junction, were the same as when the light was applied horizontally, i.e., when the light was applied parallel to the p-n junction. The short-circuit current increased by 1,75 times when two-sided illumination compared to one-sided illumination, and 2,81 times when three-sided illumination. The operating voltage of the silicon-based solar cell under double-sided illumination was 2,3% greater than that of single-sided illumination, and 4,7% greater when triple-sided illumination. In the scientific work conducted by Pal, it was

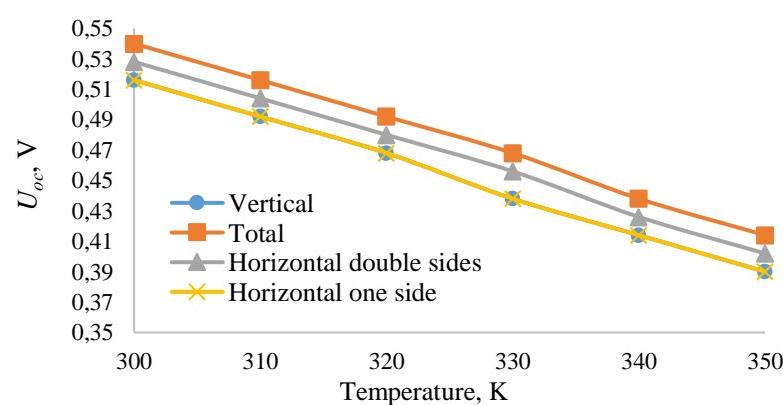
determined that the short-circuit current of a silicon-based solar cell with double-sided illumination is 20,1% to 68,1% higher than that of a single-sided one [12].



**Figure 3. Volt-ampere characteristics of a silicon-based solar cell with different areas illuminated**

The main photovoltaic parameters of a solar cell are short-circuit current, operating voltage, fill factor, maximum power and useful duty factor. To calculate these, it is enough to determine the volt-ampere characteristic of the solar cell. Therefore, in this scientific work, the volt-ampere characteristics of the solar cell at different temperatures were calculated and the dependence of the main photoelectric parameters on temperature was determined. The most temperature-sensitive photoelectric parameter is the operating voltage. Therefore, the decrease in the efficiency of the solar cell with the increase in temperature is explained only by the change in the operating voltage. Auger recombination has a greater share in

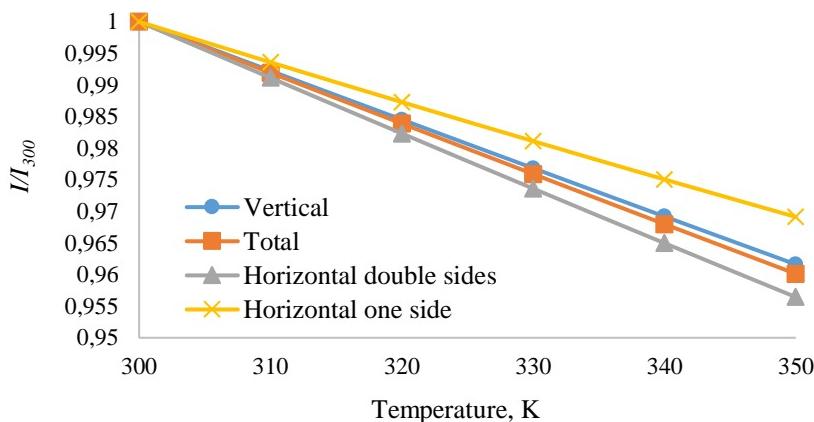
temperature-dependent changes in operating voltage than other recombination. Figure 4 depicts the temperature dependence of the operating voltage of a silicon-based solar cell with different areas illuminated. The temperature coefficient of the operating voltage for all cases was equal to the same value of  $2,52 \times 10^{-3}$  V/K. That is, it turned out that the change of the surface of the solar cell illumination does not have an effect of the operating voltage on the temperature coefficient. In the scientific work of Tiedje, it was determined that the temperature coefficient of the temperature coefficient of the double-illuminated silicon-based solar cell is equal to  $1,36 \times 10^{-3}$  V/K [13].



**Figure 4. Temperature dependence of the operating voltage of a silicon-based solar cell with different areas illuminated**

When the temperature of the solar cell changes, the concentration of phonons inside it and the concentration of electrons and electrons due to thermal generation also changes. Therefore, the short-circuit current should also change due to the dependence on the concentration of charge carriers. Figure 5 depicts the temperature dependence of the short-circuit current of a silicon-based solar cell with different areas illuminated. As shown in Figure 3 above, the short-circuit currents of double- and triple-surface illuminated solar cells are larger than those of single-surface illumination. Therefore, in Figure 4, a graph of the ratio of the short-circuit

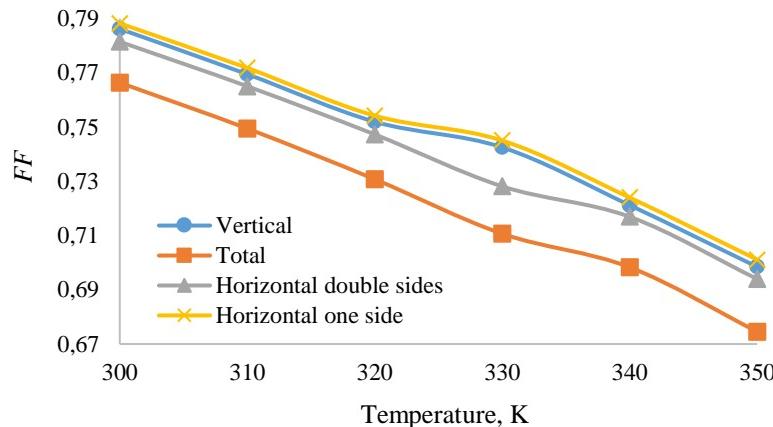
current at each temperature to the short-circuit current at 300K was created to illustrate the temperature dependence of the short-circuit current. When the temperature changes from 300 K to 350 K, it was found that the short-circuit current decreases by 3,1% when illuminated from one horizontal side, 4,4% when illuminated from two horizontal sides, 3,8% when illuminated from one vertical side, and 4% when illuminated by three surfaces. In an experimental study conducted by He Wang, the short-circuit current temperature coefficient of a silicon-based double-sided sensitive solar module under 600W/m<sup>2</sup> light was determined to be  $0,7 \times 10^{-3} \text{ K}^{-1}$  [14].



**Figure 5. Temperature dependence of the short-circuit current of a silicon-based solar cell with different areas illuminated**

The capacity of the solar cells is determined by the fill factor [15]. The value of the fill factor is mainly influenced by the resistance of the solar cell [16][17]. The main role in this is played by the quality of contacts. Figure 6 depicts the temperature dependence of the filling factor of a silicon-based solar cell with different areas illuminated[18][19]. The fill factor was 2% lower when the total surface was illuminated than when one and both sides were illuminated. An increase in the filling

factor was observed for the cases of horizontal and vertical illumination at a temperature of 330K. But for all cases, the function of changing the filling coefficient depending on the temperature has almost the same quality. The temperature coefficient of the filling coefficient was almost the same  $1.8 \times 10^{-3} \text{ K}^{-1}$  for all cases [20][21]. As the temperature increases, the filling coefficient decreases mainly due to the increase in the speed of surface recombination.



**Figure 6. Temperature dependence of the fill factor of a silicon-based solar cell with different areas illuminated**

**Conclusion.** The amount of electricity released from silicon-based solar cells increased with the increase of its illumination surface. Due to this, the concentration of photogenerated electrons and holes in it increases. When the lighting surface increased, it mainly affected the short-circuit current. The operating voltage has not changed much. The efficiency of a silicon-based solar cell decreases with increasing temperature. Also, the efficiency of the solar cell studied in this scientific

work has also decreased. When the temperature changes from 300 K to 350 K, it was found that the short-circuit current decreases by 3,1% when illuminated from one horizontal side, 4,4% when illuminated from two horizontal sides, 3,8% when illuminated from one vertical side, and 4% when illuminated by three surfaces. Therefore, the production and use of three-way sensitive solar cells in industry is appropriate.

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UDK 37.013.32 UD

## **ON TRAINING OF COMPETITIVE PERSONNEL - ON THE BASIS OF CREATING A NEW GENERATION OF TEACHING LITERATURE IN THE EDUCATIONAL PROCESS (in the example of mechanical science)**

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**Abstract:**

**Objective.** This article presents practical research results and corresponding recommendations by creating the literature of a new generation, in the education system that should be carried out so that students become mature specialists in their chosen fields. Currently, there is a strong need to study the problems of students and professors working with educational and scientific literature in the higher education institutions. to develop some methodological recommendations based on the obtained results. This article is written as a practical expression of this goal.

**Methods.** Almost no research has been done in this regard. Based on this aspect, it was found appropriate to research this issue on a scientific basis, to develop some methodological recommendations based on the obtained results. This article is written as a practical expression of this goal, and it also contains a number of recommendations.

**Results.** Based on the above requirements, there are a lot of aspects that can be studied in foreign literature and can be used in the creation of a new generation of literature in the Uzbek language. Teaching and scientific materials would be perfectly written - all the pictures, drawings and graphs used would be colorfully described in a simple and understandable way, and each elementary part is explained in detail

**Discussions.** Educational literature is created based on the priority issues of the country's development in the democratic, legal, economic, social and political directions of the development strategy and serves to further increase the intellectual potential of the schoolchildren or students, as well as advanced international experiences in the field, world science, methodology, techniques and technologies; taking into account recent achievements, development trends; Based on the above requirements, there are a lot of aspects that can be studied in foreign literature and can be used in the creation of a new generation of literature in the Uzbek language.

**Conclusion:** Effective organization of creating and working with literature of students and professors in the process of higher education requires a comprehensive approach to this issue. Proper organization of the teaching process, the further improvement of library activities, the introduction of innovative services that create a strong incentive for students to work with literature are directly related to the practice of publishing educational literature.

**Keywords:** higher education, literature, new generation, technical sciences, mechanics.

**Introduction.** Proper organization of education of students through creating new generation literature in higher education institutions, increasing their activity in working with textbooks and manuals is one of the important issues directly related to the quality of education. Currently, there is a strong need to study the problems of students and professors working with educational and scientific literature in the higher education institutions operating in our country, and to eliminate the identified problems. Because this issue, no matter how important it is, has been neglected for a long time.

**Methods.** Almost no research has been done in this regard. Based on this aspect, it was found appropriate to

research this issue on a scientific basis, to develop some methodological recommendations based on the obtained results. This article is written as a practical expression of this goal, and it also contains a number of recommendations aimed at the effective organization of this activity, the state of work of students and professors in higher education institutions with literature, its achievements and shortcomings, and using the experience of foreign countries.

**Results.** As a result of the research, the following positive aspects were observed in the activities of students and professors working with literature: — Students highly evaluate the activity of information libraries of higher education

institutions. About 75 percent of students rate the activity of information-library centers as "excellent" and "good". More than 92 percent of the total students expressed their satisfaction with the activities of the libraries. Of course, it also has an inverse relationship with the value and other outcomes based on the students' subjective assessment. Considering that a quarter of the students are not members of the library and a third of them hardly go to the library, a certain part of the high marks given means that they are disconnected from the real relationship;

**Discussions.** Three quarters (75 percent) of professors inform students about newly published educational and scientific literature in their lessons. This can enrich relevant training courses with new ideas and allow students to constantly update their knowledge. On the other hand, if this practice is used in harmony with interactive educational technologies, while informing students about changes in science, it can create conditions for lectures and seminars to pass in an intense, debate-rich spirit, and lead to the expected results in improving the quality of education;

There are general requirements for the creation of New Generation literature by professors and teachers. They are:

- Educational literature is created based on the priority issues of the country's development in the democratic, legal, economic, social and political directions of the development strategy and serves to further increase the intellectual potential of the schoolchildren or students, as well as advanced international experiences in the field, world science, methodology, techniques and technologies; taking into account recent achievements, development trends;

- Preparation of educational literature on the basis of approved state educational

standards, qualification requirements, and curriculum and science programs. It is desirable that the name of the educational literature corresponds to the name of the subjects in the curriculum.

When creating educational literature:

- the coherence and continuity between the educational types of the continuous education system introduced in the country (secondary special, vocational education, higher education (bachelor's, master's degree)) is ensured and unjustified repetition of subjects of subjects is not allowed;

- to follow the principles of consistency of subjects, transition from simple to complex, from specific to general;

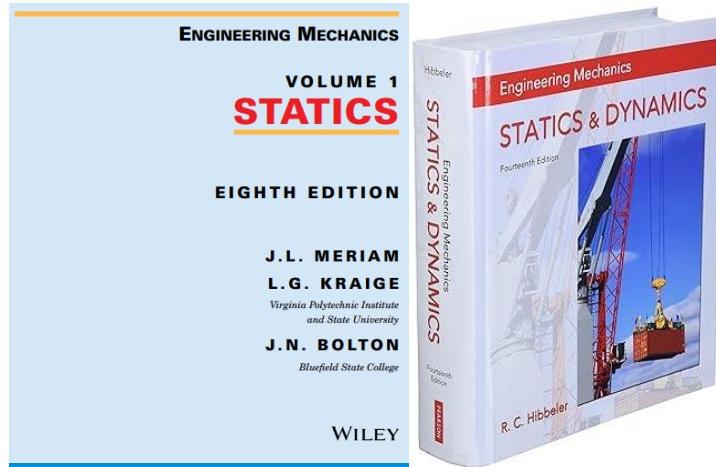
- To ensure that the content of the created educational literature is aimed at forming the skills of students and students to acquire education, independent and free thinking, gradually enriching and perfecting the acquired knowledge, independent education, searching for new knowledge from educational literature;

- Educational literature should be written in an understandable, simple and fluent language, information should be given in such a way that it is easily and effortlessly accepted by readers and students, and stored in memory, and should create an opportunity to control the knowledge and skills of students.

Based on the above requirements, there are a lot of aspects that can be studied in foreign literature and can be used in the creation of a new generation of literature in the Uzbek language.

For example, when you study the methodology of creating the literature listed below, you will see that it is perfectly written

- all the pictures, drawings and graphs used are colorfully described in a simple and understandable way, and each elementary part is explained in detail.



30 Chapter 2 Force Systems

**Sample Problem 2/2**

Combine the two forces  $P$  and  $T$ , which act on the fixed structure at  $B$ , into a single equivalent force  $R$ .

**Graphical solution.** The parallelogram for the vector addition of forces  $T$  and  $P$  is constructed as shown in Fig. a. The scale used here is 1 in. = 800 lb; a scale of 1 in. = 200 lb would be more suitable for regular-size paper and would give greater accuracy. Note that the angle  $\alpha$  must be determined prior to construction of the parallelogram. From the given figure

$$\tan \alpha = \frac{BD}{AD} = \frac{6 \sin 60^\circ}{3 + 6 \cos 60^\circ} = 0.866 \quad \alpha = 40.9^\circ$$

Measurement of the length  $R$  and direction  $\theta$  of the resultant force  $R$  yields the approximate results

$$R = 525 \text{ lb} \quad \theta = 49^\circ \quad \text{Ans.}$$

**Geometric solution.** The triangle for the vector addition of  $T$  and  $P$  is shown in Fig. b. The angle  $\alpha$  is calculated as above. The law of cosines gives

$$R^2 = (600)^2 + (800)^2 - 2(600)(800) \cos 40.9^\circ = 274,300$$

$$R = 524 \text{ lb} \quad \text{Ans.}$$

From the law of sines, we may determine the angle  $\theta$  which orients  $R$ . Thus,

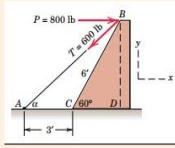
$$\frac{600}{\sin \theta} = \frac{524}{\sin 40.9^\circ} \quad \sin \theta = 0.750 \quad \theta = 48.6^\circ \quad \text{Ans.}$$

**Algebraic solution.** By using the  $x-y$  coordinate system on the given figure, we may write

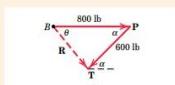
$$R_x = \Sigma F_x = 800 - 600 \cos 40.9^\circ = 346 \text{ lb}$$

$$R_y = \Sigma F_y = -600 \sin 40.9^\circ = -393 \text{ lb}$$

The magnitude and direction of the resultant force  $R$  as shown in Fig. c are then



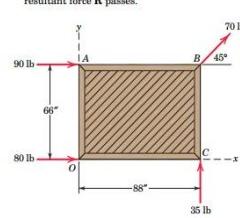
(a)



(b)

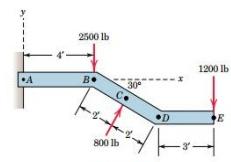
② Note the repositioning of  $F$  so as to preserve the correct line of action of the resultant  $R$ .

forces shown, determine (a) the equivalent force-couple system at  $O$  and (b) the points on the  $x$ - and  $y$ -axes through which the line of action of the single resultant force  $R$  passes.



Problem 2/90

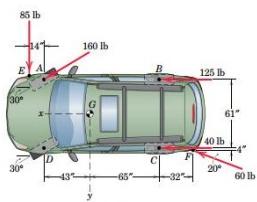
2/91 Replace the three forces which act on the bent bar by a force-couple system at the support point  $A$ . Then determine the  $x$ -intercept of the line of action of the stand-alone resultant force  $R$ .



Problem 2/91

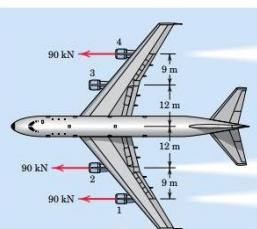
2/92 Uneven terrain conditions cause the left front wheel of the all-wheel-drive vehicle to lose traction with

Treat this as a two-dimensional problem and realize that  $G$  lies on the car centerline.



Problem 2/92

2/93 A commercial airliner with four jet engines, each producing 90 kN of forward thrust, is in a steady, level cruise when engine number 3 suddenly fails. Determine and locate the resultant of the three remaining engine thrust vectors. Treat this as a two-dimensional problem.



Problem 2/93

The problems used for every theme and the problems are taken close to their specialties for students of different fields,

which helps the students to become mature staff in their chosen professions.

Electronic addresses of foreign literature (links):

<https://sctevtodisha.nic.in/wp-content/uploads/2021/03/Engineering-Mechanics-1st-yr-LM.pdf>

[https://www.abebooks.com/9780135770405/Engineering-Mechanics-Combined\\_Statics-Dynamics-0135770408/plp](https://www.abebooks.com/9780135770405/Engineering-Mechanics-Combined_Statics-Dynamics-0135770408/plp)

<https://www.pearson.com/en-us/subject-catalog/p/engineering-mechanics-statics--dynamics/P200000003247/9780137514724>

**Conclusion:** In conclusion, it is clear from the above analysis that effective organization of creating and working with literature of students and professors in the process of higher education requires a comprehensive approach to this issue. This is determined by a number of factors, such as the proper organization of the teaching

process, the further improvement of library activities, the introduction of innovative services that create a strong incentive for students to work with literature, and the provision of ample space for problematic issues directly related to the practice of publishing educational literature.

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## MATHEMATICAL MODEL AND ANALYTICAL SOLUTIONS OF THE PROCESS OF PHYSICS-CHEMICAL HYDRODYNAMICS

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**Abstract:**

**Objective.** to describe mathematical models that calculate geo-technological indicators necessary for the management of physical-chemical hydrodynamic processes. Analyzing methods for solving these models and developing analytical solution methods.

**Methods.** methods of obtaining analytical solutions for the diffusion equation, Fourier and Laplace transformations, Green's function methods, Fourier integral, formula of cosines.

**Results.** Not all practical problems can always be solved analytically. Often, we only get solutions for special cases. In addition, the indicators considered in real conditions will be objective. For example, the area under consideration can be infinite, and the parameters involved in the model can be variable rather than constant. In this article, mathematical models of physical-chemical hydrodynamic processes suitable for mineral mixing, which is one of the geo-technological methods used in the extraction of minerals, were systematically analyzed. Compatible with these models, although there is little opportunity to find analytical solutions of the differential equation, these processes were studied because of its high efficiency and closeness to the exact solution. Analytical solutions corresponding to the obtained results were recommended.

**Conclusion.** The models chosen for the underground leaching processes correspond to its physical characteristics and they make it possible to obtain the necessary information in the process of appropriate management. Therefore, the issue of creating efficient algorithms suitable for the proposed mathematical model is considered based on numerical-approximate methods. There are several different finite-difference schemes for solving equations representing hydrodynamic processes by numerical calculation methods, and when it is necessary to choose the most effective method, obtained it will be possible to compare the results and the results obtained by the analytical method. As a result, it is possible to solve the set model in the most optimal way.

**Keywords:** physical-chemical processes, useful component, mathematical model, concentration quantity, optimization factors, Fourier integral, formula of cosines, analytical solutions, numerical-approximate methods.

**Introduction.** It is natural that the deterioration of the quality of minerals and the natural weakening of the land will lead to a rapid increase in the demand for their rational use and scientific research in the field of mineral enrichment. The complexity of the problem has led to the emergence of narrower scientific research and the inclusion of several disciplines in the field of mountain geology. They are such sciences as mathematics, mechanics, cybernetics, physics, physics-chemistry, radiation processes, microbiology.

In this regard, it is appropriate to emphasize the following tasks that must be solved:

- development of geologic-genetic models of useful component deposits and ore fields to create scientific bases for searching and forecasting high-grade ore concentrations;

- to create large-scale prediction maps in order to distinguish regions of promising mineral raw materials;

- creating a mathematical model of the production of ore deposits and making their

software packages suitable for modern computers.

The models of these processes are simultaneously represented by a system of equations of hydrodynamics, diffusion and kinetics of substance exchange. By solving the underground mixing equations, it is possible to determine the amount of product in the ore-conducting boundary layer, the nature of mixing, and the consumption of product in the internal parts. There are various methods of solving the equation, which can be divided into analytical and numerical-approximate methods.

**Methods.** The analytical solution is important because it has no error except for the error present in the finite-difference approximation. All existing solutions are valid for some cases and differ from each other for different physical processes. It follows from the complexity of the mathematical model that it is not possible to obtain an analytical solution without any simplifications.

In the same sense, the diffusion equation also has an analytical solution

only in some cases. To obtain analytical solutions, various mathematical methods are used, for example, Green's function method, Laplace or Fourier substitutions.

Suppose the one-dimensional convective diffusion problem is expressed as follows [2].

$$C_t + U C_x = K C_{xx} \quad (1)$$

$c(t=0) = 0, \quad c(x=0), \quad c(x=\infty) = 0$  let the equation be given by the initial and boundary conditions  $c(t=0) = 0, \quad c(x=0), \quad c(x=\infty) = 0$ . Here, when K and U consist of constant coefficients, it is possible to create analytical solutions of a much simpler form for the given problem. It is known that the solution was found using the Fourier substitution

$$C(x, t) = \Phi(x, t) e^{ax-bt} \quad (2)$$

is searched for in view [1]. Here, a and b are currently unknown coefficients, and to find their expression, we take special derivatives from equation (2) with respect to x and t:

$$\begin{aligned} C_x &= \Phi_x e^{ax-bt} + \Phi a e^{ax-bt}; \\ C_{xx} &= \Phi_{xx} e^{ax-bt} + 2\Phi_x a e^{ax-bt} + \Phi_x a^2 e^{ax-bt}; \\ C_t &= \Phi_t e^{ax-bt} - b\Phi e^{ax-bt}. \end{aligned}$$

We put the expression of the special derivatives into the equation in problem (1), for convenience we write e in the form without temporary degrees:

$$\Phi_t e - b\Phi e + U\Phi_x e + Ua\Phi e = K(\Phi_{xx} e + 2a\Phi_x e + a^2\Phi e).$$

We group the resulting expression with respect to the function  $\Phi$ :

$$\Phi_t = K\Phi_{xx} + (2Ka - U)\Phi_x + (Ka^2 - Ua + b)\Phi.$$

To convert the generated expression into a homogeneous parabolic type equation and to find the value of unknowns a and b, we set the coefficients in front of  $\Phi_x$  and  $\Phi$  to 0.

$$\text{Then } 2Ka - U = 0 \text{ is equal to } a = \frac{U}{2K}.$$

On the other hand, if we consider  $Ka^2 - Ua + b = 0$ , from  $K \frac{U^2}{4K^2} - U \frac{U}{2K} + b = 0$  this expression  $b = \frac{U^2}{4K}$  comes out.

We put the values of the coefficients a and b found in equation (2):

$$\Phi(x, t) = C(x, t) e^{-\frac{U}{2K}x - \frac{U^2}{4K}t} \quad (3)$$

In that case,

$$\Phi_t = K\Phi_{xx} \quad (4)$$

Equation's solution will be the formula 3.

$$C(x, 0) = f(x)$$

For this case, the solution of equation (4) when the initial distribution occurs is as follows.

$$\Phi(x, 0) = f(x) e^{-\frac{U}{2K}x} \quad (5)$$

Now we look for a general solution to equation (4).

For this, the function  $\Phi(x,t)$ . We will write as follows

$$\Phi(x,t) = X(x)T(t)$$

In that case the equation  $XT' = KX''T$  or  $\frac{T'}{KT} = \frac{X''}{X} = -\lambda^2$  will be formed.

Since each ratio depends on and is equal to different variables, they must necessarily be equal to some constant.

We create two equations from it and solve each one separately.

$$1) \quad T' + \lambda^2 KT = 0, \quad \frac{dT}{dt} = -\lambda^2 KT, \quad \frac{dT}{T} = -\lambda^2 K dt, \quad \ln T = -\lambda^2 Kt + c, \quad T = c e^{-\lambda^2 Kt}$$

2)  $X'' + X\lambda^2 = 0$  since the equation is a linear differential equation, its solution will be as follows  $X = A\cos \lambda x + B\sin \lambda x$

Then  $\Phi$  is a function which will be expressed

$$\Phi_\lambda = e^{-\lambda^2 t} (A \cos \lambda x + B \sin \lambda x)$$

Here C is included in the constants  $A(\lambda), B(\lambda)$ .

Since A and B have different values at different values of the argument, we express the solution of the linear differential equation in summation form.

$$\sum_{\lambda} e^{-\lambda^2 t} (A \cos \lambda x + B \sin \lambda x) d\lambda.$$

The sum, in turn, is expressed as an integral from 0 to infinity:

$$\Phi(x,t) = \int_0^{\infty} e^{-\lambda^2 t} (A \cos \lambda x + B \sin \lambda x) d\lambda \quad (6)$$

(5) according to the initial condition:

$$\Phi(x,0) = f(x) e^{-\frac{U}{2K} x}$$

$$(6) \text{ according to } \Phi(x,0) = \int_0^{\infty} (A \cos \lambda x + B \sin \lambda x) d\lambda$$

If we find  $f(x)$  from equation (5) and replace F with the above value, we can see that it is equal to  $f(x) = \int_0^{\infty} (A \cos \lambda x + B \sin \lambda x) e^{\frac{UX}{2K}} d\lambda$

Here we assume that the function  $f(x)$  is represented by the Fourier integral, i.e.

$$f(x) = \frac{1}{\pi} \int_0^{\infty} \left( \int_{-\infty}^{\infty} f(\xi) \cos \lambda(\xi - x) d\xi \right) e^{\frac{U\xi}{2K}} d\lambda \quad (7)$$

Or if we use the formula of the cosine of the sum:

$$f(x) = \frac{1}{\pi} \int_0^{\infty} \left( \left( \int_{-\infty}^{\infty} f(\xi) \cos \lambda \xi d\xi \right) \cos \lambda x + \left( \int_{-\infty}^{\infty} f(\xi) \sin \lambda \xi d\xi \right) \sin \lambda x \right) e^{\frac{U\xi}{2K}} d\lambda \quad (8)$$

Comparing formulas (7) and (8).

$$A(\lambda) = \frac{1}{\pi} \int_{-\infty}^{\infty} f(\xi) \cos \lambda \xi d\xi \quad (9)$$

$$B(\lambda) = \frac{1}{\pi} \int_{-\infty}^{\infty} f(\xi) \sin \lambda \xi d\xi$$

Putting the values of (9) into expression (6), we make the necessary substitutions:

$$\begin{aligned}\Phi(x, t) &= \frac{1}{\pi} \int_0^\infty e^{-k\lambda^2 t} \left[ \left( \int_{-\infty}^\infty f(\xi) \cos \lambda \xi d\xi \right) \cos \lambda x + \left( \int_{-\infty}^\infty f(\xi) \sin \lambda \xi d\xi \right) \sin \lambda x \right] e^{\frac{U\xi}{2k}} d\lambda = \\ &= \frac{1}{\pi} \int_0^\infty e^{-k\lambda^2 t} \left[ \int_{-\infty}^\infty f(\xi) (\cos \lambda \xi \cos \lambda x + \sin \lambda \xi \sin \lambda x) d\xi \right] e^{\frac{U\xi}{2k}} d\lambda = \\ &= \frac{1}{\pi} \int_0^\infty e^{-k\lambda^2 t} \left( \int_{-\infty}^\infty f(\xi) \cos \lambda(\xi - x) d\xi \right) e^{\frac{U\xi}{2k}} d\lambda\end{aligned}$$

## Results.

By changing the sign of the integral, we create the resulting formula:

$$\Phi(x, t) = \frac{1}{\pi} \int_{-\infty}^\infty [f(\xi) \left( \int_0^\infty e^{-k\lambda^2 t} \cos \lambda(\xi - x) d\lambda \right)] e^{\frac{U\xi}{2k}} d\xi \quad (10)$$

Now we calculate the integral expression in small brackets.

$$\int_{-\infty}^\infty e^{-k\lambda^2 t} \cos \lambda(\xi - x) d\lambda = \left[ z = \lambda \sqrt{kt}, dz = \sqrt{kt} d\lambda, \beta = \frac{\xi - x}{\sqrt{kt}} \right] = \frac{1}{\sqrt{kt}} \int_0^\infty e^{-z^2} \cos \beta z dz \quad (11)$$

We define the integral expression:

$$p(\beta) = \int_0^\infty e^{-z^2} \cos \beta z dz \quad (12)$$

and we differentiate:

$$p'(\beta) = - \int_0^\infty e^{-z^2} z \sin \beta z dz$$

we use the method of integration by pieces:

$$u = \sin \beta z, \quad du = \beta \cos \beta z dz, \quad dv = -ze^{-z^2} dz, \quad v = \frac{1}{2} e^{-z^2}$$

In that case,

$$p'(\beta) = \frac{1}{2} (e^{-z^2} \sin \beta z) \Big|_0^\infty - \frac{\beta}{2} \int_0^\infty e^{-z^2} \cos \beta z dz$$

The first addendum in the expression is equal to zero when setting the threshold values, and if we replace the second addendum with the expression from the original definition

$$p'(\beta) = -\frac{\beta}{2} p(\beta)$$

only the expression remains. We solve the resulting ordinary differential equation:

$$\frac{dp}{d\beta} = -\frac{\beta}{2} p;$$

$$\frac{dp}{p} = -\frac{\beta}{2} d\beta .$$

Integrating both sides:

$$\ln p = -\frac{\beta^2}{4} + c, \quad p = ce^{-\frac{\beta^2}{4}}. \quad (13)$$

Now we determine the value of the constant C. (12) from the formula

$$p(0) = \int_0^\infty e^{-z^2} dz = \frac{\sqrt{\pi}}{2}.$$

and from (13)  $p(0) = c = \frac{\sqrt{\pi}}{2}$  is obtained. So, according to formula (13), we can write the solution as follows:

$$p(\beta) = \frac{\sqrt{\pi}}{2} e^{-\frac{\beta^2}{4}}. \quad (14)$$

We put the expression (14) into (11):

$$\int_0^\infty e^{-k\lambda^2 t} \cos \lambda(\xi - x) d\lambda = -\frac{1}{\sqrt{kt}} \frac{\sqrt{\pi}}{2} e^{-\frac{\beta^2}{4}} = \left[ \beta = \frac{\xi - x}{\sqrt{kt}} \right] = \frac{1}{2\sqrt{k}} \sqrt{\frac{\pi}{t}} e^{-\frac{(\xi-x)^2}{4kt}}.$$

And finally, if we put the generated expression into the formula (10), the solution of the differential equation (4) is obtained:

$$\Phi(x, t) = \frac{1}{2\sqrt{k\pi t}} \int_{-\infty}^{\infty} f(\xi) e^{-\frac{(\xi-x)^2}{4kt} + \frac{U\xi}{2k}} d\xi. \quad (15)$$

Then the value of  $C(x, t)$  in expression (3) is equal to the following.

$$C(x, t) = e^{\frac{U}{2K}x + \frac{U^2}{4K}t} \frac{1}{2\sqrt{\pi Kt}} \int_{-\infty}^{\infty} e^{-\frac{(x-\xi)^2}{4Kt} + \frac{U\xi}{2K}} f(\xi) d\xi.$$

We make the necessary substitutions in the expression:

$$\begin{aligned} C(x, t) &= \frac{1}{2\sqrt{\pi Kt}} \int_{-\infty}^{\infty} e^{\frac{U}{2K}x - \frac{U^2}{4K}t - \frac{(x-\xi)^2}{4Kt} + \frac{U\xi}{2K}} f(\xi) d\xi = \\ &= \frac{1}{2\sqrt{\pi Kt}} \int_{-\infty}^{\infty} e^{-\frac{(x-\xi-Ut)^2}{4Kt}} f(\xi) d\xi. \end{aligned}$$

**Discussion.** So, the solution for problem (1) is found using Fourier transformation formula.

$$C(x, t) = \frac{1}{2\sqrt{\pi Kt}} \int_{-\infty}^{\infty} e^{-\frac{(x-\xi-Ut)^2}{4Kt}} f(\xi) d\xi. \quad (16)$$

will appear. Suppose that the field under consideration is bounded and satisfies the following conditions. Let  $f(x)=1$  if the domain  $|x| \leq g$  is bounded by g, and  $f(x)=0$  if the domain g is outside the domain  $|x| \geq g$ . Then expression (16)

$$C(x, t) = \frac{1}{2\sqrt{\pi Kt}} \int_{-g}^g e^{-\frac{(\xi-y)^2}{4Kt}} d\xi. \quad (17)$$

appears [3]. Marking is used here  $y = x - Ut$ . To make the integral expression more precise, we replace it with variable assignment  $z = \frac{\xi - y}{2\sqrt{Kt}}$ .

Then the differential will be appropriate  $\xi = 2\sqrt{Kt}z + y$ ,  $d\xi = 2\sqrt{Kt}dz$ .

And for the new variable  $\xi = g$ , when there are threshold values

$$z = \frac{g-y}{2\sqrt{Kt}}, \quad \xi = -g \quad \text{when} \quad z = -\frac{g+y}{2\sqrt{Kt}} \quad \text{comes out.}$$

We put all the generated values in the expression (17):

$$C(x, t) = \frac{1}{2\sqrt{\pi Kt}} \int_{-\frac{g+y}{2\sqrt{Kt}}}^{\frac{g+y}{2\sqrt{Kt}}} e^{-z^2} 2\sqrt{Kt} dz.$$

It is known that the expression of the probability integral, which is one of the special functions:

$$\operatorname{erf}(z) = \frac{2}{\sqrt{\pi}} \int_0^z e^{-t^2} dt.$$

and in order to replace the above integral with these expressions, we divide it into two parts.

$$C(x, t) = \frac{1}{2} \left( \frac{2}{\sqrt{\pi}} \int_{-\frac{g+y}{2\sqrt{Kt}}}^0 e^{-z^2} dz + \frac{2}{\sqrt{\pi}} \int_0^{\frac{g-y}{2\sqrt{Kt}}} e^{-z^2} dz \right).$$

Since the value of the integral of the probability exactly corresponds to the values under the integral and on the boundary of the integral in the expression we created, we can write the solution in the following form[2]:

$$C(x, t) = \frac{1}{2} (\operatorname{erf}(\frac{g-y}{2\sqrt{Kt}}) + \operatorname{erf}(\frac{g+y}{2\sqrt{Kt}})). \quad (18)$$

taking into account the definition  $\operatorname{erfc}(z) = 1 - \operatorname{erf}(z)$ , we can express the solution of the given problem in another way:

$$C(x, t) = \frac{1}{2} (\operatorname{erfc}(\frac{x-Ut}{2\sqrt{Kt}}) + \exp(\frac{xU}{K}) \operatorname{erfc}(\frac{x+Ut}{2\sqrt{Kt}})). \quad (19)$$

Fields of application of the obtained results. It is known that any practical problem does not always have analytical solutions. Most analytical solutions are

obtained only for special cases. In practical processes, all indicators are objective. For example, the area under consideration may be infinite, and the coefficients involved in

the equation may be variable rather than constant. In general, since it is very rare to find the solutions of all differential equations using an analytical method, in practice they are often approximated using numerical methods. Based on this, we come to the conclusion that it is necessary to find and apply numerical calculation methods that lead to effective results in order to solve any practical problem.

**Conclusion.** Thus, in this work, various methods of solving the equations representing the process and their possibilities are analyzed, specific advantages of approximate-analytical solutions and certain limitations imposed on them are presented. The approximate-analytical solution of the convective diffusion equation was derived using different substitutions: Laplace, Fourier, and Green substitutions, assuming a flat and constant filtration rate. Approximate-analytical solutions for the values corresponding to the estimated object were obtained on the basis of the working algorithms according to the Bubnov-Galerkin method, and parallel lines

corresponding to the results were drawn, and the physico-chemical properties of the process were systematically analyzed. From the obtained results, it is possible to make such decisions that the models selected for the EQ process correspond to its physical characteristics and they provide the opportunity to obtain the necessary information in the appropriate control process. For this, it is necessary to develop computational algorithms for solving this two-dimensional mathematical model in all cases. Therefore, the problem of creating efficient algorithms suitable for the proposed mathematical model is considered based on numerical-approximate methods. There are several finite-difference schemes for solving equations representing hydrodynamic processes by numerical calculation methods, and when it is necessary to choose the most effective method from them, the obtained results and the analytical method it will be possible to compare the results obtained with As a result, it is possible to solve the set model in the most optimal way.

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# MICROCONTROLLER-BASED MECHATRONIC SYSTEM WITH HEATING AND HUMIDITY SENSOR FOR SILKWORM EGGS INCUBATION

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## Abstract:

**Objective.** Silkworms have been cultivated for centuries for their valuable silk production. To ensure a successful silkworm rearing process, it's crucial to maintain precise environmental conditions during the early stage of incubation. This article explores the development and implementation of a microcontroller-based mechatronic system equipped with heating and humidity sensors for improving silkworm eggs' incubation process.

**Methods.** In this study, we designed and built a mechatronic system powered by a microcontroller to control the environmental conditions required for silkworm egg incubation. The core components of the system include a microcontroller unit (MCU), a heating element, a humidity sensor, and a user interface for monitoring and control. The microcontroller serves as the brain of the system, executing a pre-programmed algorithm to maintain optimal temperature and humidity levels. The heating element is responsible for increasing the temperature when necessary, while the humidity sensor provides real-time feedback to adjust moisture levels.

**Conclusion.** The microcontroller-based mechatronic system with heating and humidity sensors has the potential to revolutionize the silkworm egg incubation process, leading to increased silk production efficiency. Its scalability and adaptability make it a valuable tool for silkworm farmers and researchers seeking to optimize their rearing practices. Further research and development in this area may unlock even more benefits for the sericulture industry, contributing to its sustainable growth and productivity.

**Keywords:** silkworm incubation, microcontroller-based system, mechatronic system, heating and humidity sensor, hatch rate improvement, sericulture, environmental control, incubation technology, silk production, rearing efficiency.

**Introduction.** Silk, a luxurious and highly sought-after fabric, has been cultivated for centuries through the art of sericulture. At the heart of this ancient practice lies the humble silkworm, whose life cycle begins with the incubation of eggs. This critical incubation stage sets the foundation for the successful rearing of silkworms and, consequently, the quality and quantity of silk produced. Traditionally, silkworm farmers have relied on manual methods to regulate the environmental conditions required for egg incubation. However, maintaining consistent

temperature and humidity levels has always been a challenge, often resulting in suboptimal hatch rates. In recent years, the integration of advanced technology into sericulture has led to significant improvements in silkworm rearing practices. One noteworthy innovation is the development of a microcontroller-based mechatronic system equipped with heating and humidity sensors, specifically designed to address the challenges of silkworm egg incubation. This technology has the potential to revolutionize the sericulture industry by providing a reliable

and automated solution for maintaining the ideal environmental conditions.

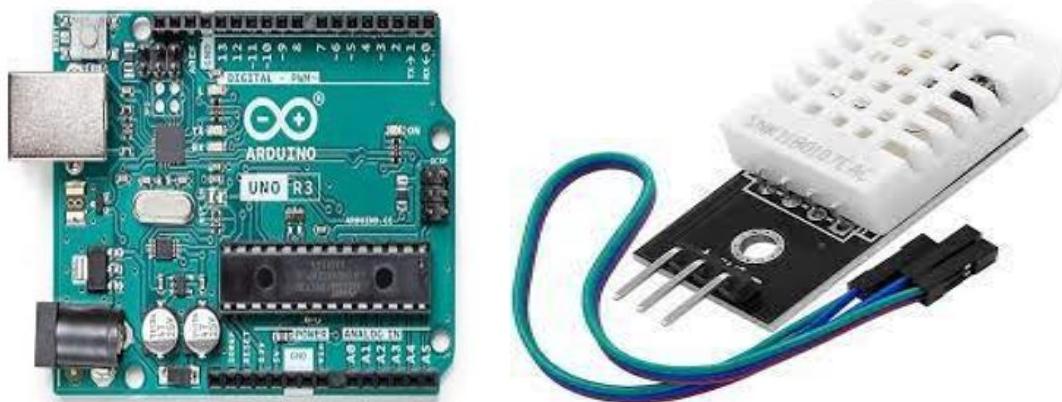
In this article, we delve into the intricate world of silkworm egg incubation, exploring the development and implementation of a microcontroller-based mechatronic system. This system combines the precision of microcontroller technology with the capabilities of heating and humidity sensors to create an environment conducive to silkworm egg development. By maintaining optimal temperature and humidity levels, this innovative approach aims to improve hatch rates and, consequently, enhance silk production efficiency. As we embark on this journey into the realm of sericulture technology, we will uncover the intricacies of the microcontroller-based mechatronic system, its components, and the potential benefits it offers to the sericulture industry. Furthermore, we will discuss the customizability of this system to accommodate different silkworm species and explore the promising prospects it brings to the realm of insect rearing practices.

**Methods.** In this section, we describe in detail the development and implementation of the microcontroller-based mechatronic system for silkworm egg incubation. System Overview: The microcontroller-based mechatronic system is designed to provide precise environmental control for silkworm egg incubation. It consists of several key components, including the microcontroller

unit (MCU), a heating element, a humidity sensor, and a user interface. Microcontroller Unit (MCU): The MCU serves as the central processing unit of the system, responsible for controlling temperature and humidity levels. We utilized an Arduino microcontroller for its reliability, ease of programming, and compatibility with various sensors and actuators. The MCU was programmed to execute a set algorithm for regulating the environment inside the incubation chamber.

Heating Element: To control temperature, we integrated a heating element into the system. A resistive heating wire was employed, positioned within the incubation chamber. The MCU controlled the heating element by modulating its power to achieve and maintain the desired temperature range. Humidity Sensor: A humidity sensor, often utilizing capacitive or resistive technology, was incorporated to measure the moisture content within the incubation chamber. This real-time data was fed back to the MCU, enabling the system to adjust the humidity level as necessary to maintain optimal conditions.

User Interface: To provide user control and monitoring, a user interface was created. This interface allowed users to set desired temperature and humidity parameters, monitor the real-time environmental conditions, and receive alerts in case of deviations from the preset values. We designed a graphical user interface (GUI) to enhance user-friendliness.



## Image 1. Arduino microcontroller and DHT 22 Sensor of temperature and humidity

**Incubation Chamber:** The physical incubation chamber was designed to accommodate silkworm eggs and maintain a controlled environment. It was constructed with appropriate insulation to minimize heat loss and prevent external environmental factors from affecting the interior conditions.

**Testing and Calibration:** Prior to implementation, the system underwent rigorous testing and calibration. Temperature and humidity sensors were calibrated to ensure accurate readings, and the control algorithm was fine-tuned to maintain stability and prevent rapid fluctuations.

**Data Logging:** Throughout the testing phase and experimental trials, data was continuously logged to assess the system's performance. Parameters such as temperature, humidity, and incubation duration were recorded for analysis.

**Experimental Setup:** A controlled experiment was conducted to evaluate the system's performance in comparison to traditional silkworm egg incubation methods. Silkworm eggs were placed in the incubation chamber, and the system was set to maintain the optimal conditions for egg development.

**Data Analysis:** The data collected during the experimental phase was analyzed to determine the system's effectiveness in maintaining stable temperature and humidity levels. Hatch rates and other relevant metrics were used to assess the system's impact on silkworm egg incubation.

**Results.** In this section, we present the findings from our experimental evaluation of the microcontroller-based mechatronic system for silkworm egg incubation.

**Temperature Control:** The microcontroller-based system demonstrated exceptional temperature control throughout the incubation period. It consistently maintained the desired temperature range of 24-26 degrees Celsius within a narrow margin of error.

**Traditional incubation methods, in contrast, often experienced significant temperature fluctuations due to external factors, such as ambient room temperature changes.**

**Humidity Regulation:** The humidity sensor, coupled with the microcontroller's control algorithm, effectively maintained the desired relative humidity levels of 75-80% within the incubation chamber. This precision in humidity control prevented desiccation or excess moisture, ensuring optimal conditions for silkworm egg development.

**Hatch Rates:** The hatch rates observed with the microcontroller-based mechatronic system were significantly higher compared to traditional incubation methods. Silkworm eggs incubated using the system consistently achieved hatch rates exceeding 90%, while traditional methods often yielded hatch rates below 70%. The difference was statistically significant ( $p < 0.05$ ).

**User-Friendly Interface:** The user interface allowed for easy monitoring and control of the system. Users could visualize real-time temperature and humidity data, adjust parameters as needed, and receive alerts in case of deviations. This user-friendly approach made the system accessible to individuals with limited technical expertise.

**Customizability:** The system's versatility was demonstrated as it could be adapted to different silkworm species and incubation requirements. By adjusting the temperature and humidity parameters, it accommodated variations in egg development stages and species-specific needs.

**Data Logging:** The continuous data logging provided valuable insights into the performance of the system. It allowed for the identification of trends and the ability to make fine adjustments to further optimize conditions.

**Statistical Analysis:** The statistical analysis confirmed that the microcontroller-based system significantly outperformed

traditional methods, particularly in terms of hatch rates.

**Discussion.** In this section, we delve into the implications, advantages, and future prospects of the microcontroller-based mechatronic system for silkworm egg incubation. Advantages of the System: The results of our experiments unequivocally demonstrate the advantages of the microcontroller-based mechatronic system for silkworm egg incubation. These advantages can be summarized as follows: Enhanced Hatch Rates: The most noteworthy benefit is the substantial improvement in hatch rates. Silkworm eggs incubated using this system consistently achieved hatch rates exceeding 90%, compared to traditional methods that often yielded rates below 70%. This increased success in hatching has direct implications for higher silk production efficiency. Stable Environmental Conditions: The system's ability to maintain stable temperature and humidity levels reduces the risk of mortality due to environmental fluctuations. This stability is vital during the sensitive egg incubation stage, where even minor deviations can lead to significant losses. User-Friendly Interface: The user interface adds an extra layer of accessibility, making the system usable by individuals with varying levels of technical expertise. This feature is valuable for small-scale sericulture operations or research purposes.

Customizability: The system's adaptability to different silkworm species and incubation requirements allows it to cater to the diverse needs of sericulture. This customization enhances its versatility and applicability. Implications for Sericulture: The successful implementation of the microcontroller-based mechatronic system has far-reaching implications for the sericulture industry: Increased Silk Production Efficiency: The higher hatch rates directly contribute to improved silk production efficiency. This could result in higher yields of silk and potentially reduce

the cost of production. Consistency in Quality: The system's ability to maintain consistent environmental conditions ensures uniformity in the development of silkworm eggs, leading to a higher quality of silk. Reduced Labor Intensity: Traditional methods often require labor-intensive monitoring and manual adjustments. The automated nature of the system reduces the need for constant human intervention, freeing up labor resources for other aspects of sericulture.

**Conclusion.** The development and implementation of the microcontroller-based mechatronic system for silkworm egg incubation represent a significant leap forward in the age-old practice of sericulture. This technology seamlessly combines tradition with modern innovation, addressing the inherent challenges of maintaining precise environmental conditions during the crucial egg incubation stage. The results of our experiments speak volumes about the potential of this system. With remarkable consistency, it achieved and maintained optimal temperature and humidity levels, resulting in hatch rates exceeding 90%. These improved hatch rates directly translate into higher silk production efficiency, a boon for sericulture practitioners and the silk industry as a whole. One of the most compelling aspects of this technology is its user-friendly interface, which allows individuals with varying levels of technical expertise to benefit from its advantages. This democratization of advanced technology in sericulture opens the door to smaller-scale operations and research endeavors. In conclusion, the microcontroller-based mechatronic system with heating and humidity sensors is a testament to the timeless art of sericulture evolving with the times. It embodies the marriage of tradition and technology, promising increased efficiency, higher quality silk, and a more sustainable future for this ancient industry.

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## METHODS OF DETERMINING TRANSPORT FLOWS

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### Abstract:

**Objective.** The study of traffic flow and its effective management holds paramount significance in contemporary urban infrastructure. Accurate methods for assessing traffic patterns are crucial for enhancing road safety, optimizing transportation systems, and alleviating traffic congestion. This article delves into the various methodologies and technologies employed for traffic detection and control. From inductive sensors to advanced computer vision systems, these techniques offer diverse strategies for monitoring and analyzing traffic.

**Methods.** This article employs a comprehensive and analytical approach to explore the methods and technologies used in traffic detection and control, primarily focusing on traffic flow analysis and management.

**Results.** Ultimately, the outcome of the research is the provision of detailed information on different sensor types and their relevance in contemporary traffic control systems.

**Conclusions.** As a result of the study of the above methods, it became clear that now video camera-based sensors are widely used and with their help we can get the necessary data for analysis. Construction of new intelligent transport systems with their help. As a result, traffic jams will be reduced, ecology will be improved, exhaust gases will be reduced, fuel consumption will be saved, and it will have a positive effect on the development of the economy.

**Keywords:** traffic flow, traffic, dynamic parameters, sensors.

**Introduction.** Traffic flow research and management play an important role in modern urban infrastructure. Accurate methods of determining traffic flows are required to ensure road safety, optimize the transport system and reduce congestion. This article explores the methods and technologies used in traffic detection and control. From inductive sensors to computer vision systems, these techniques represent different approaches to traffic monitoring and analysis. This article examines the main methods and their application in urban conditions.

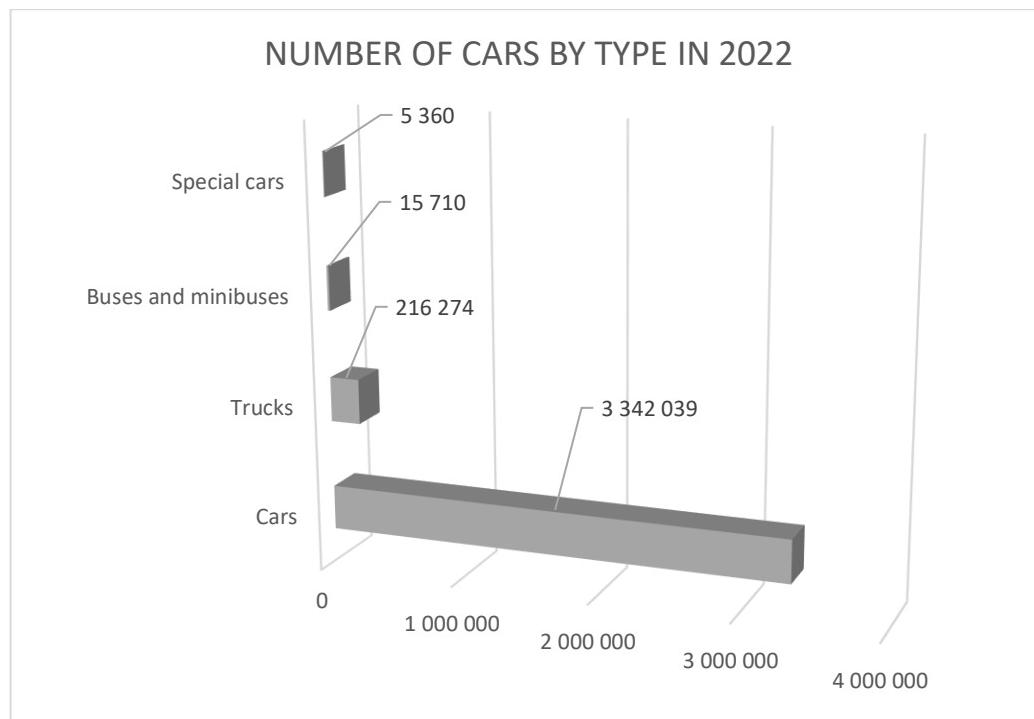
The constant increase in the number of cars on the roads requires finding solutions to optimize the flow of traffic, ensure safety and improve the

environmental situation. As a result of the increase in the number of cars, it causes an increase in traffic jams on city roads. These traffic jams, in turn, have a negative impact on the economy, the environment, and the quality of life of the population. To solve this problem, various strategies are being considered in Uzbekistan, such as the development of public transport, the improvement of road infrastructure, the introduction of new traffic management systems, and support for the development of environmentally friendly types of transport [3].

According to the data of the Statistical Agency under the President of the Republic of Uzbekistan, as of January 1, 2022, the number of cars owned by individuals was 3

million 579 thousand 384, of which 3 million 342 thousand 49 were passenger cars, 216 1 thousand 274 trucks, 15 thousand 710

buses and minibuses, and 5 thousand 360 special vehicles [1]



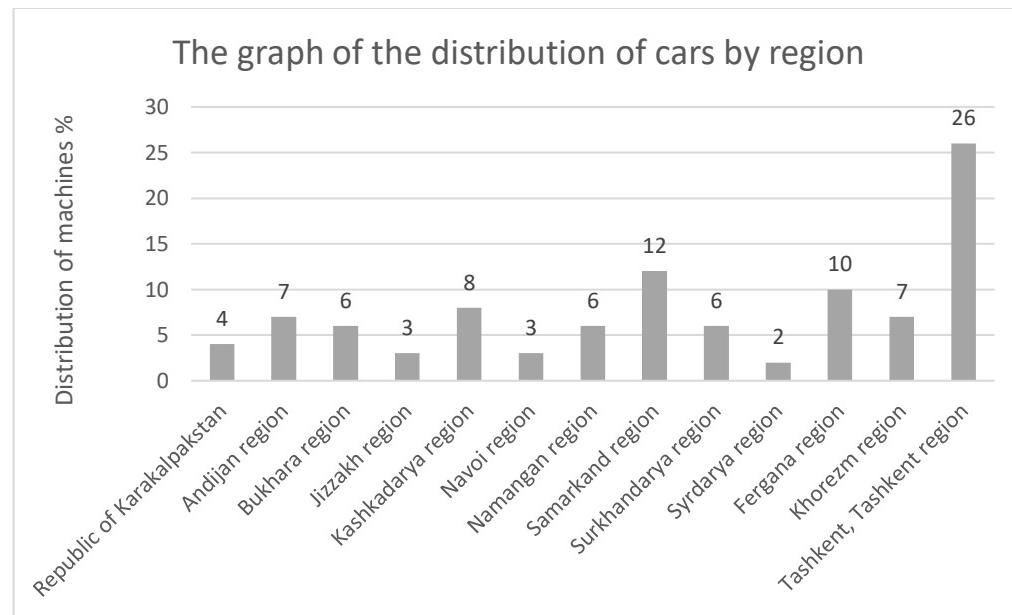
**Figure 1. Distribution of machines by type**

If we divide the above data by regions, we will create the graph below Fig. 2. From this graph, it can be seen that the number of cars in Tashkent and Tashkent region is on average 5 times more than in other regions, which causes traffic jams on Tashkent roads. The best way to avoid these traffic jams is to improve the current transport system and the number of roads, but this often requires large financial investments. Developing intelligent transportation systems is another approach to resolving this issue. Research related to the development and implementation of modern and promising technologies will remain relevant today and

in the future. The creation of such modern intelligent systems requires information of great importance.

Data are facts about things, procedures, occurrences, and specific characteristics of the topic [1, 2]

The rapid development of information technologies has made it possible to collect, refine, and process data from the traffic flow and perform some actions on it. Currently, there are several methods of obtaining data from the traffic flow, some of which have lost their importance today, while others have not yet been fully explored.



**Figure 2. Distribution of cars across regions**

Below we will consider what information from transport flows is important for building an intelligent transport system. Before that, we need to find an answer to the question "what is traffic flow?"

- traffic intensity  $q$  ( $car/h$ );
- time interval  $t(sec)$ ;
- traffic density  $p$  ( $car/km$ );
- speed  $v$  ( $km/h$ );

As you can see from the information given above, we need the information shown in the list when building an intelligent information system. We can get such information from sensors, cameras, GPS, GSM.

Traffic sensors are devices that detect the number, speed, and intensity of vehicles passing a certain road. These

A traffic flow is a set of vehicles that participate in movement at the same time on a certain part of the road network. The following key indicators are used to describe traffic flows:

sensors can be classified according to the principles of operation and installation.

According to the operating principle, traffic sensors can be divided into three groups: contact type; radiation; measurements of parameters of electromagnetic systems.

Traffic sensors are divided into two types according to their installation: on the road and sensors installed on the road.

To the sensors installed on the road:

- Electromechanical sensors;
- Magnetic sensors;
- Pneumo-electric sensors;
- Inductive sensors;

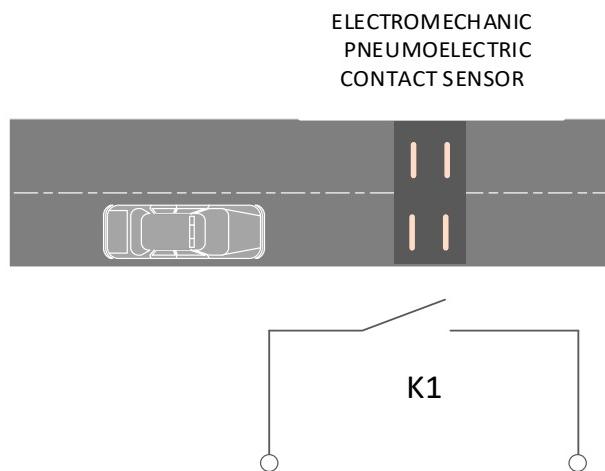
Sensors installed on the ground:

- Acoustic sensors;
- Infrared sensors;
- Radiolocation sensors;
- Includes video detector sensors;

In general, all sensors consist of 3 parts: a sensitive element (SE), an amplifier-converter and an output device (OD).

Electromechanical sensors also consist of a sensing element, an amplifier or converter, and an output device, as mentioned above. The reason why this sensor is called electromechanical is that its sensing element generates an electrical signal due to mechanical movement under

the influence of the machine. These sensors consist of two or more steel bars covered with rubber, and the sensor is installed at the same level as the road surface. When the car passes over this sensor, the contacts inside it transmit a signal to the device that is connected together, which in turn provides information that the car has passed the sidewalk where the sensor is installed. Fig. 3.



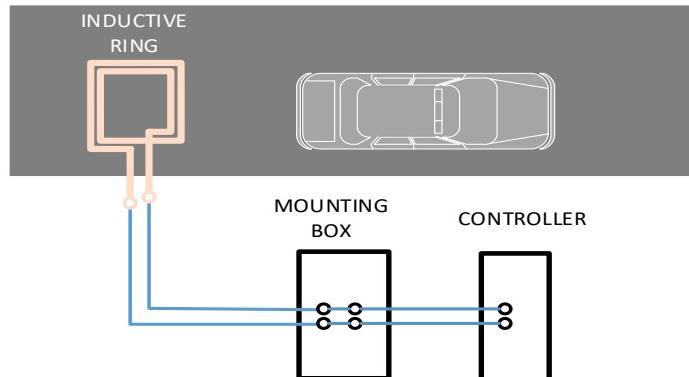
**Figure 3. The principle of operation of the electromechanical sensor**

Contact-based sensors (electromechanical, pneumo-electric, etc.) are rarely used in traffic control systems due to their low reliability, dependence on weather conditions, and the complexity of processing the received data. The sensors do not record the number of vehicles, but their wheel axles. In this case, it is necessary to divide the car into light and heavy vehicles depending on the number of axles. In some cases, it is impossible to know whether it is a truck or a car based on the number of bullets.

Among the sensors installed directly on the road surface, inductive sensors are

one of the most common ones, which differ from other types of sensors due to their simplicity of construction, reliability and low cost.

An inductive sensor (Fig. 4) is a coil of wire located on the road surface, and it can have one or more different forms. For ease of control during operation, the wire is connected to the controller, which transmits the sensor signal to the motion control system through the installation well. An alternating electric current with a frequency of 10...200 kHz is transmitted to the ring, which creates an electromagnetic field.



**Figure 4. Inductive sensor circuit**

The principle of operation of the inductive ring sensor is based on the resonant frequency change, and when the vehicle crosses this inductive ring, the frequency changes and the presence of the car is detected.

The following traffic control operations can be carried out with the support of inductive sensors:

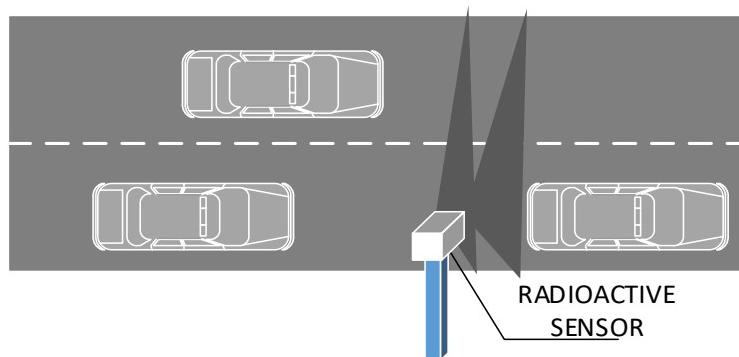
- determining the time of passage of a vehicle on a certain part of the road;
- determining the intensity of the traffic flow in any period of time;
- determining the average spatial flow speed in a certain part of the road;
- detection of traffic on a certain part of the road;
- determination of flow density in a certain part of the road;
- determining the length of the queue of cars at the intersection of the route.

On-road sensors are characterized by ease of installation, but are more expensive than inductive sensors and their accuracy is more dependent on weather conditions. Often, acoustic and infrared sensors are used to detect the presence of vehicles in this group of sensors.

Radioactive sensors can be used in flexible traffic management systems. The principle of operation of the sensor checks high-frequency signals along the way. This sensor can detect several road sections. The sensor can be installed on communication network poles and walls Fig. 5.

Radioactive sensors perform two main functions:

- Determines the presence of vehicles in controlled zones.
- Determines the dynamic parameters of the transport flow [2].



**Figure 5. Radioactive sensor**

Similar to radio-location sensors, infrared sensors are used in adaptive traffic management systems. Sensors are widely

used to determine the presence of a vehicle, its intensity and speed.

The working principle of this sensor is to detect infrared radiation.

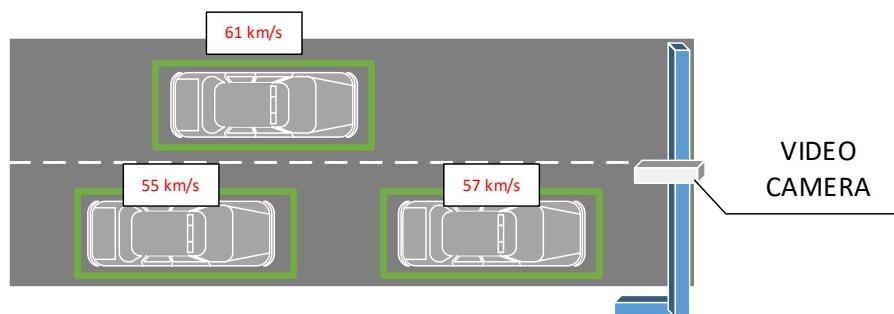
The sensor is protected against changes in light, changes in air currents, changes in temperature, voltage pulses, electrostatic discharges, and electromagnetic currents in the source circuit.

The sensor is installed on lighting poles, walls, bridges, overpasses or other artificial structures.

Among the types of sensors that are common these days are video detectors Figure 6. These systems include one or

more video cameras, whose data is processed by high-performance special software. This program provides the following set of functions to the system:

- Determines the number of cars on each road section.
- Determines the intensity of machines.
- Determined the density of machines.
- Divides machines into groups.
- Allows you to determine the speed of cars.



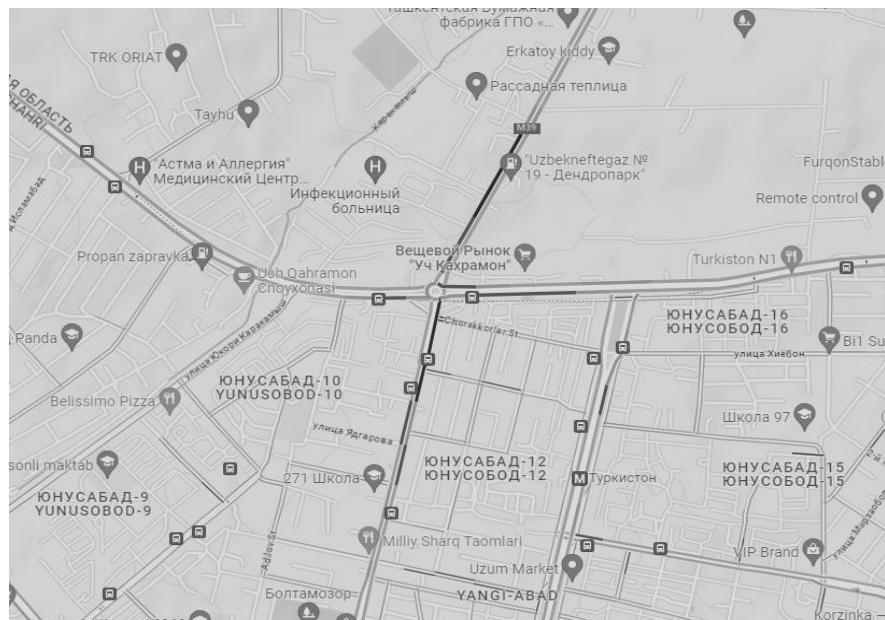
**Figure 6. Video camera-based sensor**

The advantage of the video camera-based sensor is that it can detect vehicles on up to 4 roads using one video camera and can determine all dynamic parameters of the traffic flow.

The above-mentioned sensors are now widely used in determining the flow of cars. But among these sensors, contact sensors are hardly used nowadays. The reason for this is that it is impossible to determine all the dynamic parameters of the traffic flow with the help of these sensors, contact sensors are not adapted

to weather conditions and have low reliability.

One of the developing methods for determining the parameters of the traffic flow is to determine the density, length, and intensity of the traffic flow using the geolocation of mobile phones. This method arose as a result of the development of information technologies, and it is widely used by Google and Yandex to determine and analyze traffic jams on their maps. Figure 7.



**Figure 7. Traffic analysis on Google Maps**

**Results.** The study analyzed various aspects of traffic flow in urban areas. Our results show that traffic flow is influenced by several key characteristics:

- traffic intensity
- transport interval
- traffic density
- transport speed

Our research also examined the technologies and sensors used to monitor traffic flows. The following key conclusions were drawn:

Inductive sensors. Inductive sensors are widely used due to their simplicity, reliability and cost-effectiveness. They accurately measure the presence of vehicles and are the main tool for traffic control and management.

Video Detectors: Video sensors equipped with advanced software offer a complete solution. They determine the number of vehicles, groups of vehicles and dynamic parameters, providing detailed information about traffic patterns.

Geolocation of mobile phones. New methods using mobile phone geolocation

data are being explored as potential tools for traffic flow analysis. Companies such as Google and Yandex use this approach to monitor and analyze traffic conditions.

**Conclusions.** As a result of the study of the above methods, it became clear that now video camera-based sensors are widely used and with their help we can get the necessary data for analysis. Construction of new intelligent transport systems with their help. As a result, traffic jams will be reduced, ecology will be improved, exhaust gases will be reduced, fuel consumption will be saved, and it will have a positive effect on the development of the economy.

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## PROSPECTS FOR THE APPLICATION OF VERTICAL AXIS WIND TURBINES IN THE JIZZAKH REGION

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### Abstract:

**Objective.** Foreign and local researchers analyzed the wind energy potential, technical and economic indicators of Bukhara, Navoi, Karakalpakstan, Kashkadarya and Tashkent regions. However, the information obtained as a result of the study about the potential of wind energy in the Jizzakh region, its direction and technical indicators is insufficient. In this article, analyzing the potential of wind energy in the Jizzakh region, the prospects for the use of small vertical wind energy devices are explored. Wind speed and its energy potential are the main factors in the production of electricity using wind energy devices. When using a wind energy device, it is necessary to find a point in this area with high wind speed and potential.

**Methods.** Data from NASA Power, Global Wind Atlas, and Windy international climate platforms were used to estimate the potential of wind energy.

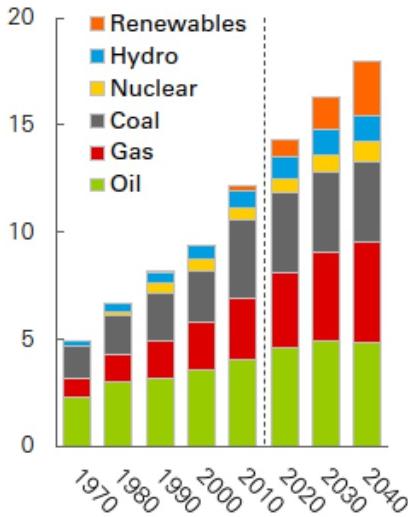
**Results.** As a result of the research, average annual wind speeds were determined for each district of the Jizzakh region and areas with the highest wind speeds within the areas. At the same time, the coordinates of points with high wind energy potential were found in areas with high wind speeds. A brief description of small-power vertical type wind turbines that can operate at low wind speeds produced by various companies is given. An optimal wind power device has been selected that can operate at low wind speeds.

**Conclusion.** When analyzing the wind energy potential of the Jizzakh region using international climate platforms, the wind speed in the Farish, Gallaral and Sh. Rashidov districts among the districts located in the Jizzakh region is higher compared to other regions. In the above districts, the use of small wind power plants is more efficient compared to other districts.

**Keywords:** Wind power device, wind speed, wind energy, Weibull distribution function, small-power vertical wind turbines.

**Introduction.** The population of the Earth is increasing from year to year, and the amount of electricity consumed by them is also increasing. To meet the ever-increasing energy consumption, extensive use of renewable energy sources in addition to existing fuels is the need of the

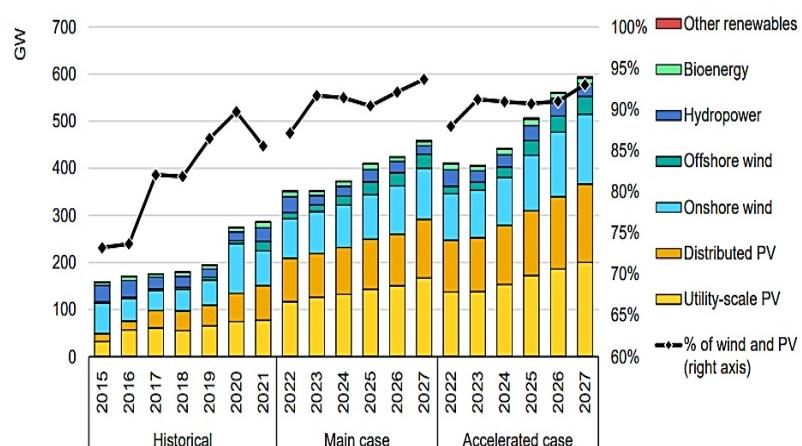
hour. The source of energy of the world since 1970 and its trained until 2040 is shown in Fig. 1. It can be observed that oil, gas, and coal were the main source of energy for the last five decades and similar trend is projected for the coming decades.



**Fig.1. Use of energy source and its transition (Renewable includes solar, wind, biomass, etc.)[1]**

Annual renewable capacity additions are forecast to increase continuously over the forecast period, reaching a record 460 GW in 2027 in the main case, 60% higher than last year's growth. At the end of the forecast period, solar PV and wind provide the vast majority of global renewable

capacity additions in 2027, accounting for nearly 95% as technology-specific challenges and limited policy support hamper faster expansion of hydropower, bioenergy, geothermal, CSP and ocean technologies Fig.2.



**Fig.2. Renewable annual net capacity additions by technology, main and accelerated cases, 2015-2027[2]**

The increase in demand for energy resources on a global scale has given a great impetus to the development of wind energy. Wind power capacity in operation around the world contributed an estimated 7% of total electricity generation in 2021 fig 3. 93.6 The top five global markets for new installations in 2022 were: China, USA,

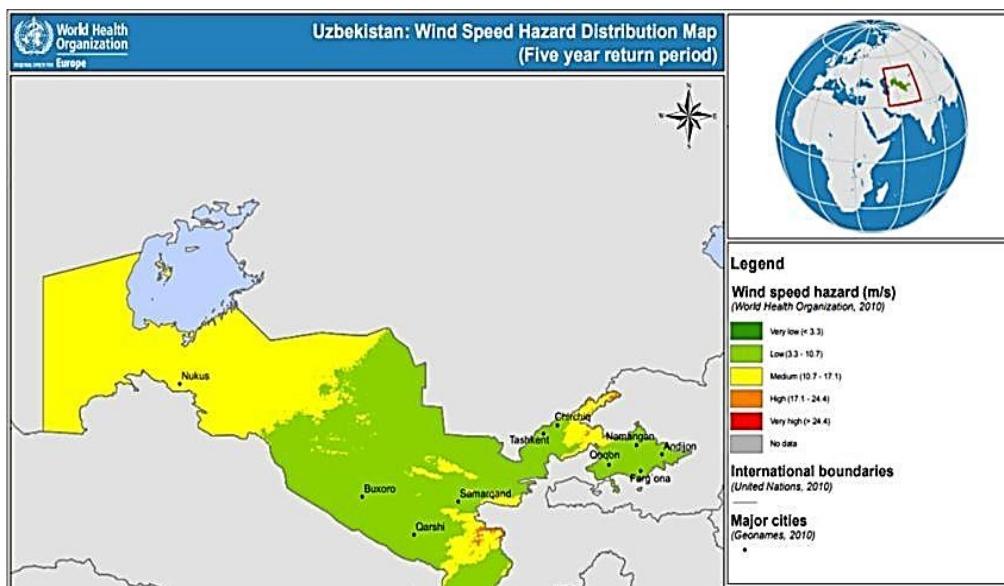
Brazil, Germany and Sweden. Overall, they accounted for 71% of global installs last year, down 3.7% from 2021. This was primarily because the world's two largest markets, China and the US, lost a combined market share of 5% year-over-year, the second year in a row that both countries lost market share.



**Fig. 3.Wind Power Global Capacity and Annual Additions, 2011-2021**

Given the fact that water sources in the Central Asian region are declining, it is important to accelerate the use of alternative energy. Uzbekistan has the opportunity to use wind energy, but previously this renewable energy sector was not among the priority areas for the development of local energy. At the beginning of the 21st century, national and foreign experts summarized previously known information, conducted a new series of observations necessary to assess the local and regional environmental situation, the risks associated with the movement of air masses (about 90 meteorological

stations operate on the territory of the country, which provided the results of systematic observations for 1994 -2004 and other periods, mainly at altitudes up to 10 m). As a result, in the mid-2000s, the gross potential was estimated at 2.2 million toe. per year, technical - 0.4 million toe. per year (five times less), and economic - as "insignificant". Below in the figure 4. one of the variants of the wind map of the Republic of Uzbekistan is shown. Its analysis allows a general idea of the nature of the distribution of wind energy potential within the territory of the country.



**Fig.4. Uzbekistan: Wind Speed Hazard Distribution Map[4]**

The first wind turbine with a capacity of 170 kW and a cost of more than 2 million US dollars was built in 2010 near the Charvak reservoir. Design documentation was prepared by Hydroproject OJSC, equipment was supplied by Doojin Co. (The Republic of Korea). The second (experimental, but the first large on the scale of Central Asia) Chinese-made wind turbines was installed in 2012 in the Yubileiny settlement of the Bostanlyk district (Tashkent region). Its power is 750 kW, the diameter of the wind wheel is 50 m, the height of the tower is 65 m. In 2012, based on the experience gained, Uzbekenergo JSC planned to create a wind farm with a capacity of 100 MW, generating about 170 million kWh of electricity per year. Subsequently, the implementation of the plan was delayed by ten years for various reasons, including the lack of reliable comprehensive indicators of wind energy potential. According to experts, the gross potential of wind energy has exceeded 520 GW (this is the possible total capacity of wind turbines), which theoretically allows generating 1,077,651 GWh of electricity per year. Promising development areas include the Navoi region and sites located in the Republic of Karakalpakstan near remote settlements and the small industrial zone "Muynak" (created in 2017 on the territory of the former "Muynak fish cannery" and the largest in Central Asia). From a technical point of view, according to the recommendations of the researchers, the most optimal solution is the use of wind turbines with a capacity of 3 MW and a rotor diameter of 100 m. Specific capital investments in the creation of 1 MW of wind power capacity were estimated at 1 million US dollars (comparable to the same indicator for thermal power plants), the cost of wind power was approximately 5.5 q/kWh. In the Republic of Uzbekistan, in cooperation with international financial institutions, feasibility studies have been carried out in the field of widespread use of wind energy and the "Concept of Electricity

Supply of the Republic of Uzbekistan for 2020-2030" has been developed. One of the main goals is the construction of wind power plants with a capacity of 3000 MW by 2030 in the republic. Today, several projects on the construction of SPPs have been launched in Uzbekistan. Including:

Based on an agreement signed on April 1, 2021, Masdar Clean Energy of the United Arab Emirates and the Ministry of Energy of the Republic of Uzbekistan reached an agreement on the construction of a 500 MW wind farm in the city of Tomdi district of the Navoi region. With a project cost of \$600 million, the wind farm will generate 1.8 billion kWh of electricity per year at full capacity. Two more large projects are being implemented by ACWA Power Company of Saudi Arabia, and one of these projects, according to the contract signed between ACWA Power Company and the Ministry of Energy on January 23, 2021, provides for the construction of two wind power plants with a total capacity of 1 GW in Gijduvon and Peshkun districts of Bukhara region. The second project with the participation of this company is based on the agreement signed between the Ministry of Energy and ACWA Power (Saudi Arabia) on December 23, 2022 with the financial support of the European Bank for Reconstruction and Development, and works on the construction of another wind power plant with a capacity of 1500 MW in Beruni and Karauzyak regions of Karakalpakstan. When this wind farm is operational, it will produce 350 million kWh of electricity per year. On March 28, 2023, a memorandum of understanding was signed between China's CNEEC (China National Electric Engineering Company), China Huadian Overseas Investments, SANY Renewable Energy and the Ministry of Energy to study the possibilities of building wind power plants with a capacity of up to 1000 MW in Jizzakh region. According to this memorandum, 1 billion US dollars will be directly invested in the implementation of the project[5].

### **Methods. Analysis of wind potential of the region.**

Uzbekistan, a double landlocked country with no coastal area, consists of 25% mountainous valleys and 75% desert covered oasis. Therefore the average yearly wind speed on the whole territory of the country is estimated between 2-2.5 m/sec, which indicates a non-promising future for wind power engineering in U

zbekistan, especially for wind turbines of middle and high power.

Consequently the wind energy potential in Uzbekistan is relatively less exploitable in comparison with the solar and hydropower potential (table1)[6].

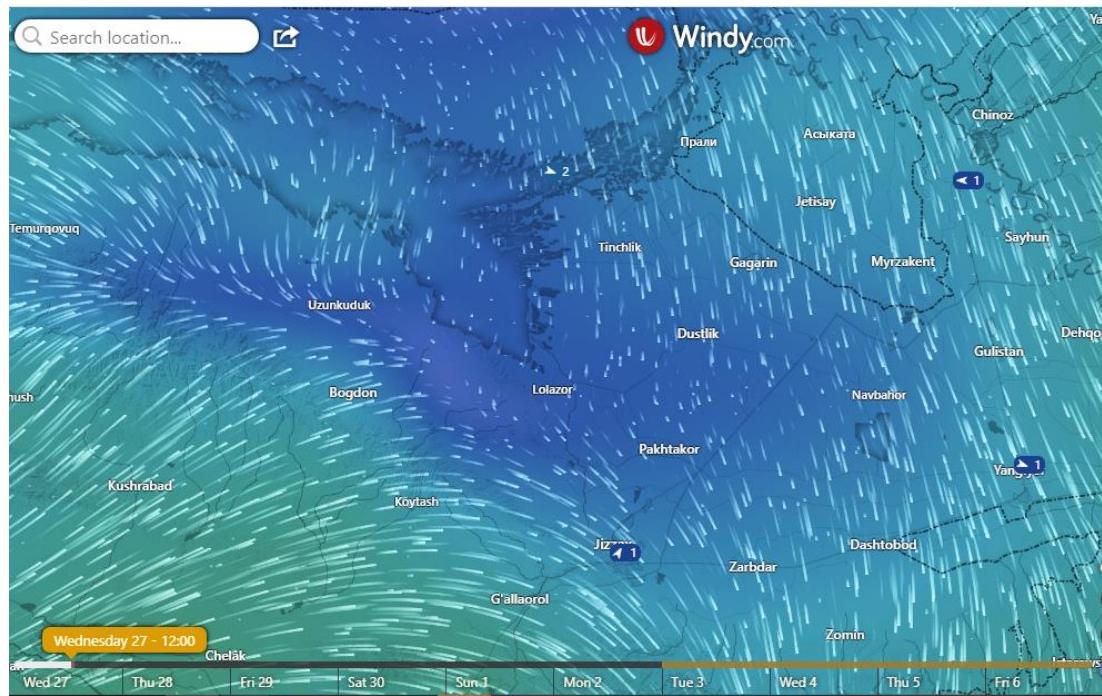
Even in the provinces with a reasonable potential wind resource is very seasonal and it is necessary to study the coincidence between peak wind months and the electricity demands.

Table 1

<b>№</b>	<b>Province</b>	<b>Area of wind resource km<sup>2</sup></b>	<b>Gross potential W/m<sup>2</sup></b>	<b>Gross energy GWh/year</b>
1	Karakalpakstan Rep.	1649	93	10752.20
2	Andijan	42	20	60.00
3	Bukhara	294	90	2421.80
4	Jizzakh	205	49	649.60
5	Kashkadaryo	284	58	1162.00
6	Navoi	1108	104	7931.40
7	Namangan	79	28	155.40
8	Samarkand	164	61	690.60
9	Surkhandaryo	208	30	434.80
10	Sirdaryo	51	58	212.00
11	Tashkent	156	100	1066.00
12	Fergana	71	34	49.60
13	Khorazm	63	55	264.00
<b>Total</b>		4474	84	25849.00

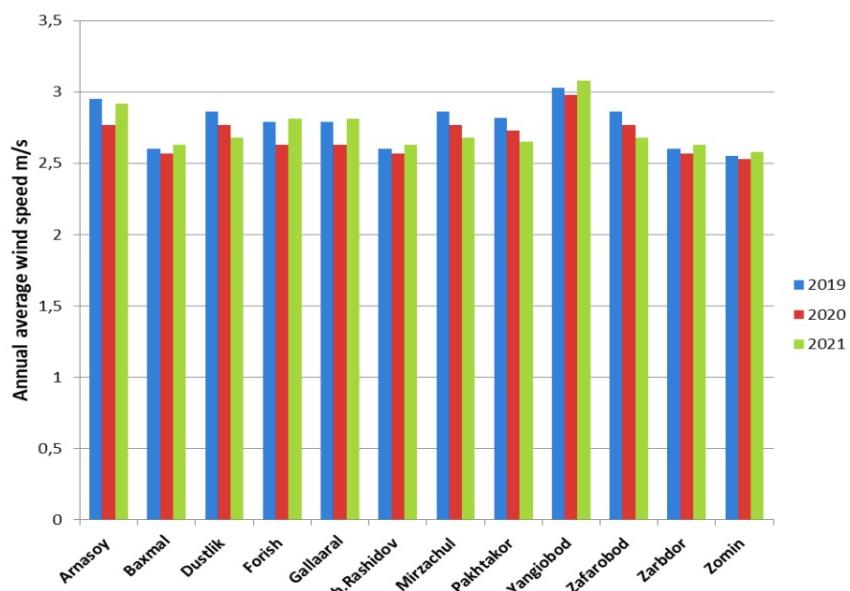
Jizzakh region is located in the center of Uzbekistan. The region borders on the Republic of Kazakhstan in the north and northeast, Syrdarya region in the east, the Republic of Tajikistan in the east and southeast, Samarkand region in the south and southwest, and Navoi region in the west[7]. Air currents that affect the climate of the region are predominantly northwestern and southwestern air

currents. The northwesterly air flow comes from the north from the western part of Russia and Kazakhstan and is 34.5 days a year. The south-west air flow also has a great influence on the climate of the region and is 63.2 days a year. Fig. 5. shows the direction of the north-western air flow entering the territory of the Jizzakh region[8].



**Fig.5. The direction of the north-west air flow[9]**

Based on the data obtained from the NASA POWER international geographic database and the MERRA-2 satellite, annual average and monthly average wind speed in districts located in Jizzakh region at a height of  $h=10$  m shown in Fig.6.



**Fig.6. The average annual wind speed at height of  $h=10$  m**

It can be seen that the wind speed is higher in Armasoy and Yangiabod districts of Jizzakh region compared to other districts. In particular, the wind speed in Yangiabod district will change from 3.03 m/s to 3.08 m/s in 2019-2021, and from 2.95 m/s to 2.92 m/s in Armasoy district. Also in 2019-2021, the wind speed in the Forish district changes from 2.79 m/s to 2.81 m/s, and in the Gallaorol region - from 2.79 m/s to 2.81 m/s. The

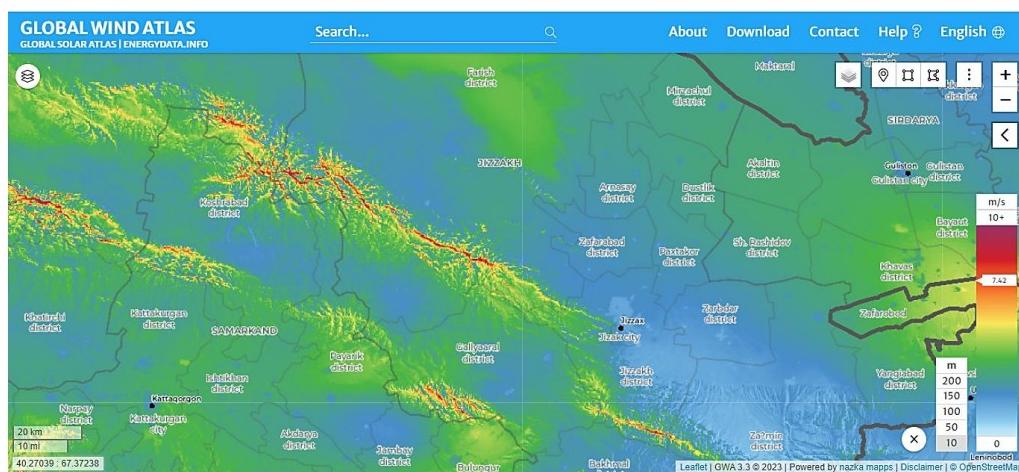
wind speed is low in Zomin district, the average annual wind speed in 2019-2021 is 2.55-2.58 m/s (Table 2).

**Table 2**

Districts	Latitude(°)	Longitude(°)	Annual average wind speed (m/s)		
			2019	2020	2021
Yangiobod	39,9	68,7	3,03	2,98	3,08
Arnasoy	40,5	67	2,95	2,77	2,92
Farish	40,04	67,4	2,79	2,63	2,81
Gallaaraal	40	67,6	2,79	2,63	2,81
Dustlik	40	68	2,86	2,77	2,68
Mirzachul	40,6	68,1	2,86	2,77	2,68
Zafarobod	40,3	67,8	2,86	2,77	2,68
Pakhtakor	40,3	67,9	2,82	2,73	2,65
Baxmal	39,7	67,9	2,6	2,57	2,63
Sh.Rashidov	40	67,8	2,6	2,57	2,63
Zarbdor	40	68,1	2,6	2,57	2,63
Zomin	39,9	68,4	2,55	2,53	2,58

Based on the data presented in Fig. 8 and Table 2, it can be seen that the average annual wind speed at the points indicated in the coordinates is 2.5-3 m/s. This speed is not enough to generate electricity using a wind power plant. The operating range of the wind energy device takes values between 3 and 10 on the

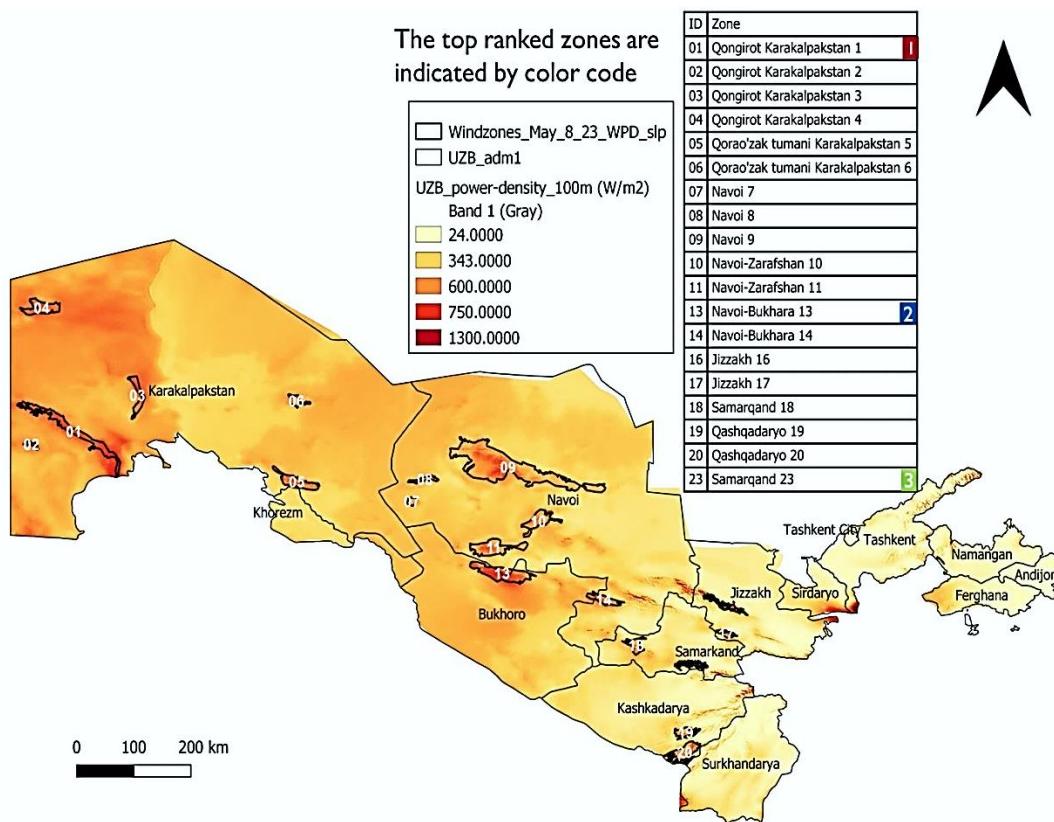
Beaufort scale (Table 3). Therefore, the value of the wind speed should be higher than 3.5 m/s when using a wind energy device to produce power up to the rated value. In this case, it is necessary to determine the points where the wind speed is higher than 4 m/s.



**Fig.7. Points with high wind energy potential**

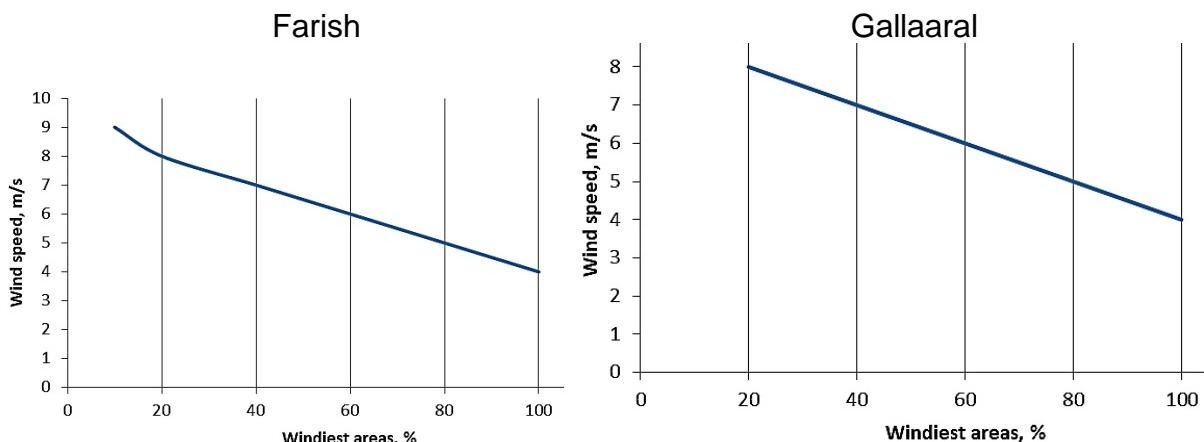
Based on the data obtained from the Global Wind Atlas, there are points with a wind speed of 4 m/s and higher, and these points are located in the mountainous points of Forish, Gallaaraal and Sh.Rashidov districts of the region(Fig 7,9)[10]. Also, the research

conducted by the USAID international organization of the USA shows that the points with high wind energy potential in the Jizzakh region correspond to the territory of Farish, Gallaraal and Sh.Rashidov districts. (Fig. 8)[11].



**Fig.8. Updated wind energy zones by USAID/Tetra Tech. [12]**

The wind speed at these selected points is given below (Fig. 10).



**Fig.9. Wind speed at selected points**

It can be seen from the data presented in Fig. 10 that the wind speed varies in the range of 6-8 m/s at the windy points located in the mountainous regions of 3 districts. This change covers a

selected area in Forish district, where the wind speed is 20% at 8 m/s, and 40% when the wind speed is 7 m/s. For Gallaraal district, it is 20% when the wind speed is 8 m/s, and 60% when the wind

speed is up to 5 m/s. For Sh.Rashidov district, when the wind speed at the points located in the mountainous area is 6 m/s, the windy area is 20%, and when it is 7 m/s or higher, the values are up to 10%.

Around the world, horizontal wind turbines are mainly used in the production of large-scale electricity from wind energy. It is also possible to use a horizontal type wind power device to supply electricity to household consumers. When using a horizontal type wind power device, it is

necessary to take into account the speed, direction and frequency of the wind. The use of horizontal wind turbines in areas where the direction and speed of the wind changes is technically and economically inefficient. In regions with variable wind direction and speed, it is effective to use vertical wind power devices. The advantages and disadvantages of vertical wind energy devices can be listed as follows[13]:

### VAWT advantages

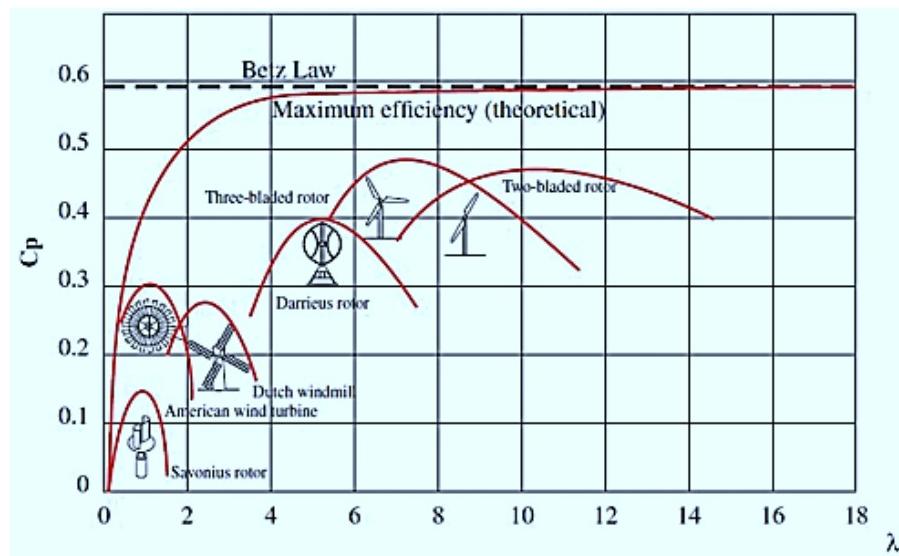
- No yaw mechanisms is needed.
- VAWTs have lower wind startup speeds than HAWTs.
- VAWTs may be built at locations where taller structures are prohibited.

### VAWT disadvantages

- VAWTs have low efficiency.
- More blades than HAWTs.
- VAWT advantages.

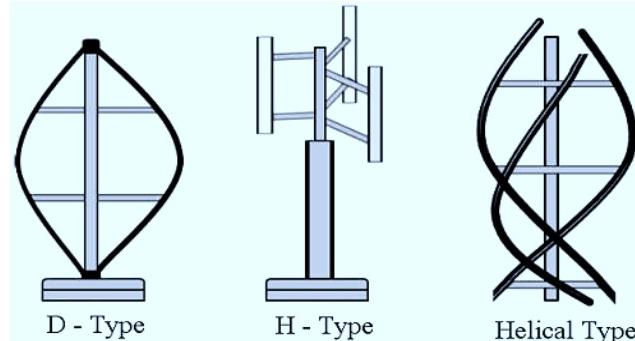
Despite the existence of different constructions of vertical type wind energy devices, they can be divided into two large groups: Savonius vertical wind turbines and Darrius vertical wind turbines. Savonius turbines working on the aerodynamic drag principle and excellent in areas of turbulent wind and can self-start at

low wind speed. Darrieus turbines were operating on the principle of lift. The efficiency of Savonius type wind turbines is lower than that of Darrius type wind turbines. According to Betz's law, the efficiency of the Savonius turbine is up to 20%, and the efficiency of the Darrius wind turbine is up to 40%. Fig 11.[14]



**Fig.10. Betz law. Ideal turbine coefficient**

Darrieus rotor can be subdivided into three categories; D – type, H – type and helix type which have been shown in Fig. 12 [15].



**Fig.11. Different types of Darrieus wind turbine**

**Discussion.** Unlike other energy sources, wind energy efficiency is high. Therefore, the theoretical and technical potential of wind energy is taken into account when using wind energy potential. The theoretical potential of wind energy is determined by the following expression[16]:

$$W_{theoretical} = 0,025 \rho TS \sum_{i=1}^n v_i^3 t_i , \quad (1)$$

here,  $\rho$  is air density,  $\text{kg/m}^3$ ;  $T = 8760$  hours during the year;  $S$  – area surface,  $\text{m}^2$ ;  $v$  – i multi-year wind speed in the range;  $t$  – I approximate wind speed in the range.

Technical potential of wind energy:

$$W_{technical} = 0,01 \frac{N_C}{D^2} TS, \quad (2)$$

here,  $N_C$  – the average power of the wind turbine and it is expressed as follows:

$$N_C = \frac{\pi D^2}{8} \rho \sum_{i=1}^n v_i^3 \eta_{VAWT} t_i , \quad (3)$$

here,  $\eta_{VAWT}$  efficiency index of VAWT

$$\eta_{VAWT} = c_p \eta_{mech} \eta_{el} , \quad (4)$$

here,  $c_p$  - wind energy utilization factor;  $\eta_{mech}$  - mechanical efficiency of the wind turbine;  $\eta_{el}$  – electrical efficiency of the wind turbine.

The amount of electricity produced by a wind turbine:

$$E = 0,01 T \sum_{i=v_{switch\ on}}^{v_{switch\ off}} P_{VAWT\ i} (k_h v) f_i (v), \quad (5)$$

Useful power of the wind turbine:

$$P_{VAWT} = P_{flow-specific\ power} S_{VAWT} \eta_{rotor} \eta_{generator} \sigma 10^{-3}, \quad (6)$$

Flow-specific power,

$$P_{flow-specific\ power} = 0,5 \rho (k_h v)^3 \quad (7)$$

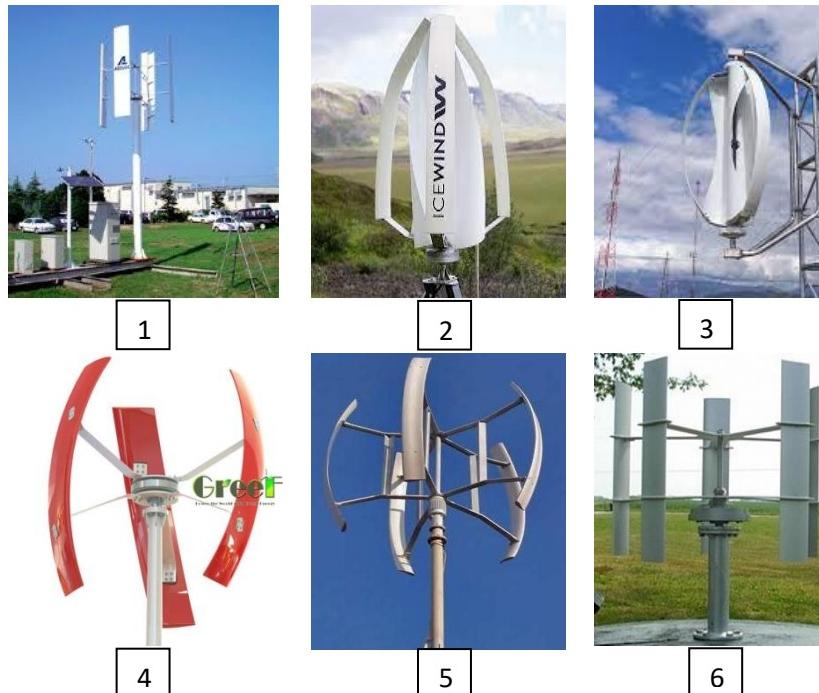
In the production of electricity from wind energy, the working range of wind speed is used. This working range should not exceed 25 m/s. This speed is equal to 9 points on Beaufort's 12-point scale. Wind turbines generally operate between 3 and force 10 on the Beaufort scale and the rated capacity is commonly defined at forces 6/7 depending upon the wind turbine type[17].

**Results.** The conducted research shows that the annual average speed of the wind blowing in the Jizzakh region does not exceed 2.5-3 m/s at a height of  $h=10$  m.

It can be determined that the wind speed is 6-8 m/s in the mountainous regions of Farish, Gallaraal and Sh, Rashidov districts. Therefore, in some areas of the above 3 districts, there is a possibility of using vertical type wind energy devices. The use of H-type turbines, which are modern modifications of the Darrieus wind turbine, is efficient compared to the Savonius-type vertical wind power plant. We will analyze some types of modern H-type vertical wind energy devices produced by different companies and their technical characteristics for regions with high wind

potential. Companies that produce vertical small power wind energy devices offer wind energy devices with different capacities and characteristics. In particular, 1-Aeolos company (Great Britain) Aeolos – V5 (1), 2-3-Ice wind (USA) CW 100 and RW 100, 4-Greef New Energy Equipment Co., Ltd

(Canada) GW 500, 5-Qingdao allrun new energy co. (China) ARC 3000, 6-United Solar Technologies (Russia) Sokol Air Vertikal-3kW(6) models are among them (Fig. 13). Table 4.[18-22] below shows the technical parameters of the vertical H-type wind energy devices named above.



**Fig. 12. Different models of vertical axis wind turbines**

**Table 4**

Manufacturer	Model	Rated Power (kW)	Start-up wind speed (m/s)	Rated wind speed (m/s)	Working wind speed (m/s)	Survival wind speed (m/s)	Material	Output Voltage (V)
Aeolos	Aeolos V5	5	1,5	10,0	1,5-10	52,5	Aluminum alloy	220
Ice wind	CW 100	0,1	2	10	2-10	60	Fiber Reinforced Plastic	-
Ice wind	RW 100	0,16	2	10	2-10	60	Fiber Reinforced Plastic	-
Greef New Energy Equipment Co., Ltd	GW500	0,5	1	10	1-25	-	Fiber Reinforced Plastic	-
Qingdao allrun new energy co., ltd	ARC 3000	3	2,5	9	2,5-25	50	Glass Fiber Reinforced Plastic	220
United Solar Technologies	Sokol Air Vertikal	3	2	7,5	3-20	-	Aircraft-grade aluminum	220/380

Analyzing the VAWT models presented in Table 4, it is possible to make sure that the models capable of operating at the smallest initial wind speed are GW500 (1 m/s), Aeolos V5 (1.5 m/s) and Sokol Air Vertikal (2 m/s). The rated speed of these models is 10 m/s Aeolos V5, GW500 and 7.5 m/s (Sokol Air Vertikal). Also, the rated speed of the ARC 3000 vertical wind energy device is small compared to other models and is 9 m/s. Taking into account the speed of the wind blowing in the mountainous part of Farish, Gallaraal and Sh.Rashidov districts, the production of electricity using the Sokol Air Vertical wind power plant is effective compared to other models of this type.

**Conclusion.** This study provides information on the potential of wind energy

in the world and in Uzbekistan, as well as on the projects launched to develop wind energy in the country. [10-12] by analyzing the data obtained from international databases, the wind energy potential of Jizzakh region was analyzed. Based on the conducted theoretical studies, it was determined that 3 out of 12 districts of the region have a high wind energy potential compared to other districts. The possibilities of using a vertical-type wind energy device for these districts were considered. As a result, it was theoretically analyzed that the use of Sokol Air Vertical wind energy devices in the production of electricity using the potential of wind energy in these districts is the optimal solution.

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## PROBLEMS AND POSSIBILITIES OF LASER SYNTHESIS OF METAL POWDERS IN ADDITIVE TECHNOLOGIES

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### Abstract:

**Objective.** To carry out research on the production technology of powder materials used in the production of products with additive technology, to apply the obtained results for the purposes of powder metallurgy.

**Methods.** The mechanical methods of obtaining metal powders are studied in the article, and the properties of formation without significant changes in the chemical composition of the powder material are highlighted.

**Results.** Depending on the aggregate state of the initial components in the reaction zone, results were obtained for three main types of the reaction process: solid-phase, non-gaseous and gaseous types. It was found that during the solid phase reaction, the metal particles in the powder mixture retain their original size. It was found that the reaction rate of gasless combustion does not depend on pressure and the constant mass of the formed particle is maintained. The dependence of the gas combustion reaction rate on pressure and the change in the mass of powder particles during the process were determined.

**Conclusion.** In the process of mechanochemical synthesis, it is necessary to take into account the increase in the volume fraction of the three-sided bond boundary with the decrease in the size of the particles.

In the process of preparing the powder material, its positive feature is its low temperature and high speed fusion, while maintaining its plasticity with the reduction of the particle size. The reduction of the particle size reduces the porosity of the powder, which increases the density and strength of the prepared product.

**Keywords:** additive, ultraviolet, laser, powder, synthesis, layer, particles, growth, mechanochemical, combination.

**Introduction.** Currently, humanity is entering the period of the fourth industrial revolution, which is characterized by the

structure of cyber-physical systems in production processes. The natural, biological and digital integration of

scientific technology is making new breakthroughs in fields such as artificial intelligence, robotics, nano and biotechnologies, energy, materials science and others. The process of layer-by-layer melting of metal powder from these technological bases is carried out in an automated mode, according to a computer model. In this case, for obtaining and for resources, except for the intermediate stages of production and mold production, there is no parting and finishing labor cost of loading [1].

**Literature analysis.** Advanced industrial enterprises are conducting scientific research studies on the technological processes of layer-by-layer synthesis of metal, metal-ceramic and nanostructured powder compositions.

The first creative approach to additive technology began in 1956 with the production of a method of selective (layer-by-layer) synthesis of transparent photographic emulsion by Professor Otto Munz of the University of California. In 1981, R.F. Housholder proposed a method of forming a thin layer of powdered material on a flat platform by water. support this year Hideo Kodama announced the support of the first functional photopolymerization systems using ultraviolet light and laser. In 1982, A.J. Herbert created 3D models using an ultraviolet lamp and a system of mirrors along the X-Y coordinate axes.

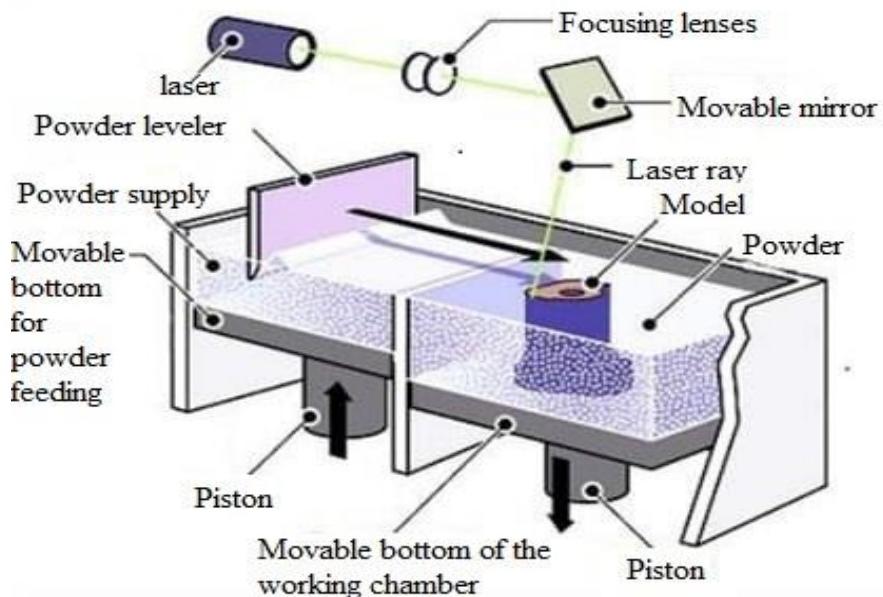
In the mid-1990s, the first stereolithographic (SLA machines) laser machines were developed, followed by powder (SLS machines). These machines were mainly used in research and development related to the defense industry, because the cost of the machine was too expensive, which changed the cost of production. , in 1995, MIT students Jim Bredt and Tim Anderson pioneered the

development of this technology by introducing layer-by-layer material production into a traditional desktop printer body [1,2].

Therefore, industrial enterprises are actively adopting additional technologies. In this scientific research work, in architecture and design offices, in design studios, and in individual personal development of individual products. Additive in many colleges and universities (layer-by-layer growth machine) machines or 3D printers are an integral part of the curriculum for professional engineering education.

**Research object and methodology.** With SLA (Steriolithography Apparatus), laser stereolithography - photopolymerization technology: it is possible to obtain a high-resolution basic model of a casting detail, thin-walled body details of micro-instruments and high-resolution membranes (valves). This technology is also very promising in the current situation. The continuous development of photopolymer materials, which are the main raw materials, allows to obtain more details with different technical characteristics.

The principle of operation of this technology is that the material is introduced into the annealing chamber in the form of powder, and the minimum material layer is leveled with a roller to the permissible thickness, then the laser melting process begins by heating the material up to the melting temperature, after which the powder layer corresponding to the geometry of the part shape is selected with laser beams. during the melting stage, the shape of the detail on the sample is grown to a height equal to the thickness of the powder layer (Picture. 1).

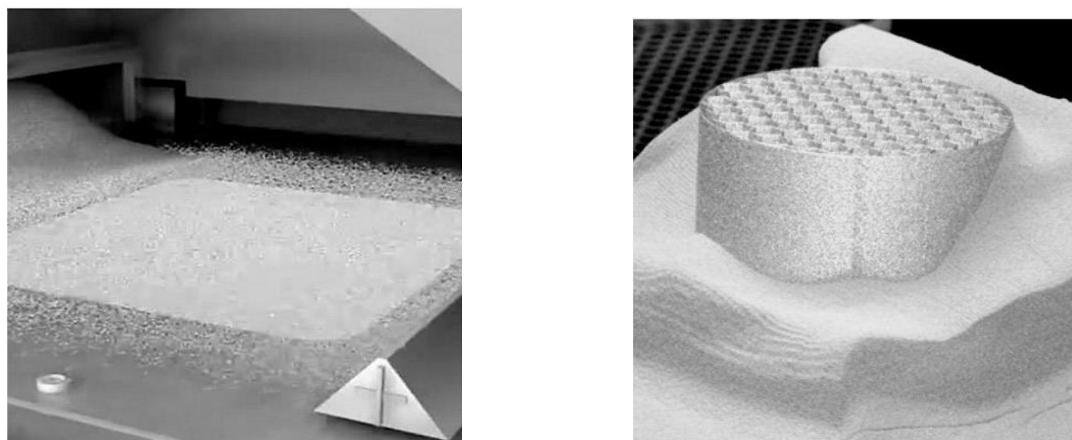


**Picture 1. Scheme of the process of growing a three-dimensional model by the method of laser stereolithography**

At the next stage, a new layer of powder is introduced into the heating chamber, the stage of selective melting of the layer with laser beams is repeated, and the section of the detailed shape is grown to a height equal to the thickness of another layer of powder. Thus, the detail is grown layer by layer until the complete shape is formed. In the process of product preparation with additive technology, the conditions and method of growing the detail form are described through the

source of energy, processing speed, physico-chemical properties of the material and other indicators (Picture. 2).

There are no established standards for the production of powder materials used in the production of products with additive technology, and there is no possibility of application due to the presence of anisotropy in materials obtained by traditional technologies. A general requirement for a powder material is the spherical shape of the particles.



a)

b)

**Picture 2. Preparation of products from powder material by the method of selective laser melting: a - spreading a layer of powder on the work surface; b - the process of layer-by-layer growth of the detail form**

The spherical shape ensures a more compact distribution of particles of a certain size, as well as uniform flow of powder material into the working chamber with minimal resistance [3].

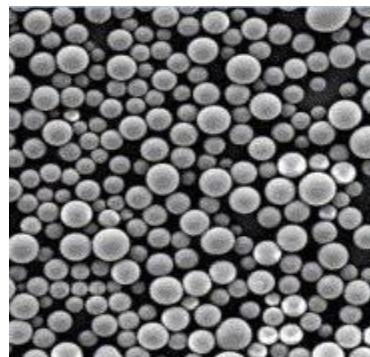
The problem of obtaining powder materials is relevant not only for the development of additional technologies, but also for the purposes of powder metallurgy. Metal powder compositions are used in high-tech industries such as aircraft engineering, space technology, shipbuilding, energy, military and instrument engineering.

**Analysis and results.** There are physico-chemical and mechanical methods of obtaining metal powders in industry: - the chemical composition and

structure of the powder is significantly different from the original material. Mechanical methods ensure the production of powder from raw materials without significant changes in chemical composition. Mechanical methods include many types of grinding, such as grinding in mills, as well as dispersion of solutions using a gas or liquid stream, a process also called atomization. Particles of powder obtained by mechanical grinding have a fragmented, irregular shape. The produced powder contains a relatively large amount of foreign impurities, so these methods are not used to obtain powders used in additional technologies (Picture. 3a).



a)



b)

**Picture 3. Depending on the method of obtaining the powder material, the appearance of the morphology and texture of the particles: a) obtained by a mechanical method powder particles; b) powder particles obtained by melt dispersion method**

Melt dispersion is the most economical and effective way to obtain small and medium-sized metal powders. 60-70% of the volume of all industrial powders is obtained by this method. Atomization is widely used in the production of powders of multi-component alloys with an amorphous structure, which makes it possible to achieve the same chemical composition in the main alloy component of the composition, even if the composition of the alloy components is above the solubility limit. In addition, powder particles obtained using melt

dispersion methods have a spherical shape [3,4].

The size, morphology and texture of the particles differ depending on the technological parameters of the nanomaterials production process (Picture. 3a,b).

As the particle size decreases, the volume fraction of the triple junction boundary increases, and the volume fraction of triple junctions with particle sizes below 10 nm increases significantly. It has a significant effect on the properties of the structure determined by the methods

of preparation of nanocrystalline materials (particle size, percentage of junction boundaries, porosity, etc.). Reduction in particle size while maintaining its plasticity, its strength increases, the effect of superplasticity is manifested at low temperatures and high speeds (Picture. 3b).

A macro picture describing the process of synthesis of metal compounds is typical for "cold" and "high temperature" synthesis. The difference between "high-temperature" synthesis and "cold" synthesis is that as a result of "high-temperature" synthesis, favorable conditions for spontaneous combustion are created, and the subsequent synthesis process is carried out due to the heat of the chemical reaction [5,6].

Let's consider the simplest case, when the synthesis process is carried out in the form of a single compound between two components:  $A+B \rightarrow AB$ . We conditionally define the melting and boiling points of the initial components, respectively  $T_A$ melting,  $T_V$ ering,  $T_A$ boiling,  $T_B$ boiling, combustion temperature -  $T_{Yonish}$ , depending on the ratio of  $T_{Yonish}$  to  $T_A$  and  $T_B$ , the aggregate state of the initial components changes and the reaction is different mechanisms can be implemented.

Depending on the aggregate state of the initial components in the reaction zone, there are three main types of reaction processes: solid-phase, non-gaseous and gaseous.

**Solid phase combustion mechanism.** A characteristic feature of solid-phase reactions is that the reaction takes place only in the solid phase, without the participation of liquid, and the reaction rate is extremely low. According to the aggregate state of the reactions, the transition condition of the solid-phase reaction is as follows:  $T_{Yonish} < T_A$ . This combustion mechanism is carried out in carbides, borides, silicides and intermetallic compounds. Most often, the solid-phase combustion mechanism

occurs in systems containing hard-to-melt metals such as tungsten, tantalum, molybdenum, and niobium. Hardly soluble metals (Ta, Nb, Mo), mixed with boron and carbon were detected in the powder in the process of self-propagating high-temperature synthesis (CBC) in the solid-phase gasless combustion method [8].

During the solid-phase reaction, deep synthesis does not occur, the metal particles in the powder mixture retain their original size. It was found that the combustion mechanism in the solid state without gas is very sensitive to changes in operating parameters at the site of the reaction process (deterioration of the interaction between particles, an increase in the size of particles and a decrease in the combustion temperature) [5,6,7].

**Gasless combustion engine.** The peculiarity of this mechanism is that the speed of the synthesis reaction during the process does not depend on the pressure and the constant mass of the formed particle is maintained. Depending on the ratio of cooling of the initial components depending on the melting and boiling temperatures, the process takes place in different ways, in which we consider two cases:

**Case A.**  $nA + mB = AnBm$  reaction participants react in the liquid phase with the condition ( $n, m \geq 1$ ). The transition condition for such a reaction is  $T_A$ erish  $< T_{Yonish} > T_V$ erish,  $T_{Yonish} > T_A$ Verish. is represented by the inequality This case includes the following compounds: borides ( $TiB, TiB_2, ZrB_2, HfB_2, VB_2, CrB_2, NiB$ ), silicides ( $Ti_5Si_3, Zr_2Si, Zr_5Si_3, ZrSi$ ),  $Al$  intermetallic compound, and  $MnS$  sulfide. State A is characterized by the release of heat as a result of the formation of some compounds, which is sufficient not only to melt the initial component, but also to convert it into a vapor state. For example, the temperature during combustion of  $Ti + 2B$  mixture

Temperature rises to  $2927^{\circ}C$ . Thus, with high values of  $T_{Yonish}$ , when the pressure of one of the components

exceeds atmospheric pressure, the vacuum allows to "turn off" the explosive mechano-chemical synthesis of a hard-to-dissolve compound.

Case B. One of the participating components reacts in a liquid state, and the other in a solid state. The transition condition for this state is represented by TAerish<Tyonish<TVerish. This situation is most typical for the formation of titanium, zirconium, hafnium and silicon carbides. As a result of the carbide synthesis reaction, the metal melts and the carbon becomes solid. In the case of the self-propagating high-temperature synthesis (CBC) process, the interaction of the liquid metal with the carbon creates a capillary diffusion effect, which results in a dramatic acceleration of the burning rate. According to the conducted studies, mixtures burning with the effect of capillary diffusion have the highest propagation speed of the combustion wave, which in some cases leads to thermal explosion. At the same time, it is clear from the calculated and experimental results that during the explosive mechano-chemical synthesis, the temperature sufficient to melt titanium actually occurs.

Gas combustion engine. A characteristic feature of this combustion mechanism is the dependence of the combustion speed on the pressure and the change in the mass of the reagents during the process, in which we consider two cases:

Case A. The conditional regime in the form of TAboling < Cooling < TVboiling can be performed in Me-gas (N<sub>2</sub>, H<sub>2</sub>, O<sub>2</sub>) systems, as well as in Me-S, Me-P systems.

Case B. A conditional mode of rest > TAB can also be performed in the Mg + S system.

The gaseous combustion mechanism can be performed only for

some nitrides, sulfides, as well as oxides. In the case of (CBC), most of the nitrides are synthesized using this mechanism, the mechanochemical synthesis of nitrides is carried out under nitrogen atmospheric pressure. The gaseous combustion mechanism in the (CBC) process has been developed for most nitrides, hydrides, and oxides. In mechanochemical synthesis, according to explosive kinetics, the interaction of metal with gas was determined only in the environment of interaction of metals with oxygen [9,10,...16].

**Conclusions.** Based on the results of the studied and conducted research, we make the following conclusions: - the technical requirement for the particles of the powder material is that they should be spherical in shape. The spherical shape of the particles ensures uniform distribution of a powder layer of a certain volume and uniform flow transfer to the working chamber with minimal resistance;

- in the process of mechanochemical synthesis, with a decrease in the size of the particles, the volume fraction of the three-way junction boundary increases, the volume fraction of the three-way junctions increases significantly with particle sizes less than 10 nm;

- as a result of the significant influence on the characteristics of the structure (particle size, compound boundary fraction, porosity, etc.) determined during the preparation of the powder material, the strength increases while maintaining the plasticity with the reduction of the particle size, low temperature and high speed the effect of plasticity is manifested;

- the reduction of the particle size reduces the porosity of the powder, which increases the density and strength of the prepared product.

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## DETERMINATION OF ACCEPTABLE VALUES OF THE MAIN FACTORS AFFECTING THE PRODUCTION OF TWISTED THREAD

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**Abstract:** In this article, the limit parameters of the main factors affecting the performance of the improved working part of the yarn winding machine were determined, and their optimal values were determined by the method of mathematical planning. These values were graphed and analyzed for the effect of the machine on yarn stiffness.

**Keywords.** Textiles, tenacity, spinning, yarn, yarn cooking, acceptable values, factors, yarn tension, yarn winding speed, puck weight.

**Introduction.** Increasing competition in the world market of textile products, improving the quality of products due to the development of production technologies in countries producing textile raw materials and increasing the productivity of equipment and technologies, as a result of ensuring resource efficiency in industrial enterprises, is increasing the need for wide use of expensive raw materials. Accordingly, in order to improve the quality of products and reduce their cost in the field of textile production in the world market, it is of great importance to identify and eliminate the factors that have a negative effect on the operation of technological processes in one of the main processes - spinning and thread preparation for weaving, as well as the creation and introduction of automated, resource-efficient modern machines. [1,2].

Creation of the scientific basis of the techniques and technologies of the preparation and cooking of spun yarns, the

development of normative technological parameters with a detailed study of the scientific and technical capabilities of modern machines and equipment suitable for the production process are gaining special importance in the world. In this regard, it is of urgent importance to carry out targeted scientific research on changing quality and strength indicators by cooking yarns from the spinning process, producing cooked yarns that meet market requirements, ensuring resource efficiency in the production of cooked yarns, and reducing the cost of manufactured products [3].

The yarn splicing process is graded by splicing the yarn at the same length and tension. As influencing factors of the splicing technological process, the input factors  $x_1$  - thread tension, sN,  $x_2$  - thread winding speed, m/min,  $x_3$  - puck weight, grams, indicators were taken. The choice of levels and intervals of the studied factors is presented in Table 1.

Table 1  
**Selection of levels and intervals of changes in the factors under investigation**

Name and designation of factors	Change levels			Change interval
	-1	0	+1	
$x_1$ - thread tension , sN	250	400	550	150
$x_2$ - thread winding speed, m/min	350	500	650	150
$x_3$ - puck weight, grams	14,2	20,1	26	5,9

The parameters of change were obtained as test results to determine the hardness and shrinkage of the studied yarn. Based on the central non-composite test matrix, 15 different test cases of 3 fighting factors were accepted for analysis and evaluated according to the test results (Table 2).

Table 2  
**Central non-composite experience matrix**

№	Factors			$x_1x_2$	$x_1x_3$	$x_2x_3$	$x_1^2$	$x_2^2$	$x_3^2$	$Y_1$	$Y_2$	$S_u^2(Y_1)$	$S_u^2(Y_2)$
	$x_1$	$x_2$	$x_3$										
1	+	+	0	+	0	0	+	+	0	1185	3,8	68,4	0,98
2	+	-	0	-	0	0	+	+	0	921	6,8	29,8	1,2
3	-	+	0	-	0	0	+	+	0	951	7,2	48,9	0,68
4	-	-	0	+	0	0	+	+	0	695	11,5	62,7	1,26

5	+	0	+	0	+	0	+	0	+	1105	7,8	39,4	1,4
6	+	0	-	0	-	0	+	0	+	958	8,2	74,6	1,9
7	-	0	+	0	-	0	+	0	+	924	7,6	68,4	0,89
8	-	0	-	0	+	0	+	0	+	768	11,6	49,7	0,62
9	0	+	+	0	0	+	0	+	+	1108	5,8	52,7	0,14
10	0	+	-	0	0	-	0	+	+	995	7,8	72,6	0,97
11	0	-	+	0	0	-	0	+	+	820	8,2	67,4	0,78
12	0	-	-	0	0	+	0	+	+	701	10,5	94,2	0,38
13	0	0	0	0	0	0	0	0	0	1105	6,8	82,4	0,02
14	0	0	0	0	0	0	0	0	0	1128	5,9	76,9	0,14
15	0	0	0	0	0	0	0	0	0	1139	6,1	98,4	0,11

In order to determine the regression coefficients, Student and Fisher's criteria were used to check the adequacy of the mathematical model. As output factors,  $Y_1$  was selected according to the hardness (N) of the thread [4].

Based on the results of the experiment, we look for a second-order regression multifactorial mathematical model. As a result of this experiment, the regression model of the following general form can be obtained:

$$Y_R = b_0 + \sum_{i=1}^M b_i x_i + \sum_{\substack{i=j=1 \\ j \neq 1}}^n b_{ij} x_i x_j + \sum_{i=1}^M b_{ii} x_i^2$$

Or, since three factors are involved in our experiment, the above expression takes the following form:

$$Y_R = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_{12} x_1 x_2 + b_{13} x_1 x_3 + b_{23} x_2 x_3 + b_{11} x_1^2 + b_{22} x_2^2 + b_{33} x_3^2$$

Taking into account the determined regression coefficients, the equation is written as follows:

$$Y_{R1} = 1124 + 103,88x_1 + 137,75x_2 + 66,88x_3 + 2x_1x_2 - 2,25x_1x_3 - 1,5x_2x_3 - 77,75x_1^2 - 94,12x_2^2 - 93,75x_3^2$$

It is known that if the calculated value of the criterion is smaller than the table value, then that coefficient is not significant and it is removed from the equation. In research  $b_{12}$ ,  $b_{13}$ ,  $b_{23}$  It turned out that the coefficient is insignificant for the studied parameters:

The equation with significant coefficients is rewritten:

$$Y_{R1} = 1124 + 103,88x_1 + 137,75x_2 + 66,88x_3 + 77,75x_1^2 + 94,12x_2^2 - 93,75x_3^2$$

The resulting  $Y_1$  is an adequacy test of the equations for determining the significance of the regression coefficients on yarn hardness. The test is performed using Fisher's test. The estimated value of Fisher's criterion is determined. The calculated value of the factor being optimized is calculated by putting the coded values of all the columns of the  $Y_1$  equation matrix (-1, 0 and +1). Values are taken row-wise, not column-wise. The calculations for formula Y are as follows, and the calculation results are included in Table 3.

Table 3  
Calculation results of values coded into the equation for adequate dispersion

№	Y <sub>1</sub> - The hardness of the thread (N)			Y <sub>2</sub> - According to the elongation at break (%).			
	Y <sub>1i</sub>	Y <sub>1ii</sub>	(Y <sub>1i</sub> -Y <sub>R1i</sub> ) <sup>2</sup>	Y <sub>2i</sub>	Y <sub>2ii</sub>	(Y <sub>2i</sub> -Y <sub>R2i</sub> ) <sup>2</sup>	
1	1185	1194	8,8	76,7	3,8	4,89	1,09
2	921	918	-2,7	7,5	6,8	7,99	1,19
3	951	986	35,0	1225,0	7,2	7,71	0,51
4	695	711	15,5	240,3	11,5	10,8	-0,69
5	1105	1123	18,3	333,4	7,8	6,99	-0,81
6	958	990	31,5	992,3	8,2	7,37	-0,83
7	924	916	-8,5	72,3	7,6	8,01	0,41
8	768	782	13,7	188,8	11,6	12	0,39
9	1108	1141	32,8	1073,2	5,8	5,59	-0,21
10	995	1007	12,0	144,0	7,8	7,77	-0,03
11	820	865	45,3	2048,5	8,2	8,69	0,49
12	701	732	30,5	930,3	10,5	10,9	0,37
							0,14

$$\sum_{u=1}^{N-N_s+1} (Y_{R1.u} - \bar{Y}_{1u})^2 = 7332,146$$

$$S_{nad}^2\{Y_1\} = \frac{7332,146}{4} = 1833,04$$

$$\sum_{u=1}^{N-N_s+1} (Y_{R2.u} - \bar{Y}_{2u})^2 = 5,428$$

$$S_{nad}^2\{Y_1\} = \frac{5,428}{4} = 1,36$$

It is known that if the calculated value of the criterion is smaller than the table value, then that coefficient is adequate and proves that the calculations were carried out correctly [5,6]

$$F_{R1} = \frac{S_{nad}^2\{Y\}}{S^2\{\bar{Y}\}} = \frac{1833,04}{128,85} = 14,2$$

$$F_{R2} = \frac{S_{nad}^2\{Y\}}{S^2\{\bar{Y}\}} = \frac{1,36}{3,135} = 10,01$$

$$F_j \left[ P_D = 0,95; f\{S_{nad}^2\{Y\}\} = 15 - 6 - (3 - 1) = 5; f\{S_u^2\} = 3 - 1 = 2 \right] = 4,74$$

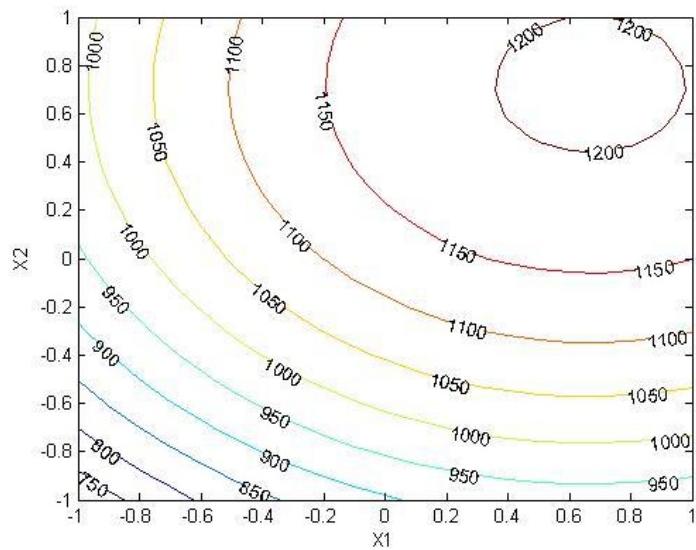
$$F_{R1} = 14,21 < 19,25 = F_j \quad F_{R2} = 10,01 < 19, = F_j$$

Therefore, obtained regression mathematical models represent the researched process with sufficient accuracy.

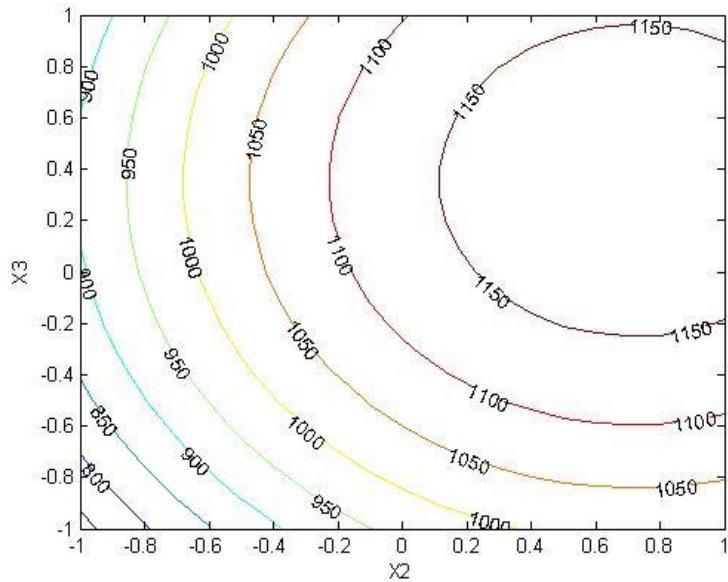
**Research results.** Since the equation constructed to determine the

characteristics of the output parameter for the study is three-dimensional, one of the input factors in the analysis is assumed to be  $X_i=0$  (central state), and we construct a two-dimensional graph by transforming the models into 3 equations [7].

$$Y_{R1} = 1124 + 103,88x_1 + 137,75x_2 + 66,88x_3 + 77,75x_1^2 + 94,12x_2^2 - 93,75x_3^2$$



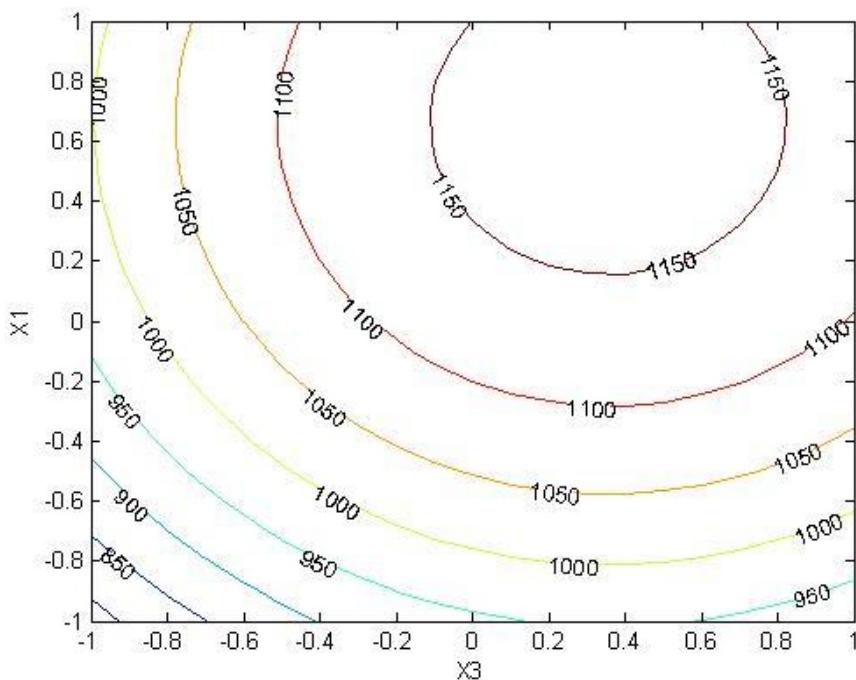
**Figure 1. Graphs of the yarn tension dependence model of yarn winding speed**



**Figure 2. Graphs of the model of the dependence of the weight of the puck on the speed of winding the yarn**

The graphs in Figure 1 illustrate the effect of two  $x_1$  (yarn tension) on yarn stiffness as a function of  $x_2$  (yarn winding speed). As in any experiment, in this study, the influence of the input factors was studied. The output parameter  $Y_1$  values should be selected in the case of maximization.

The graphs in Fig. 2 show the effect of two other main factors  $x_2$  (winding speed) on yarn stiffness as a function of  $x_3$  (puck weight). In this case, the study of the effect of two factors on the output parameter was carried out using the method of small experiments, and the main values were determined through optimization.



**Figure 3. Graphs of the model of the dependence of the string tension on the weight of the puck**

The graphs in Figure 3 illustrate the effect of  $x_1$  (thread tension) on thread stiffness as a function of  $x_3$  (puck weight). We determine the output parameter values for all cases.

**Summary.** In these studies, the deviation of the surface of the isolines obtained from the yarn tension (sN), yarn winding speed (m/min) and puck weight (grams) in the yarn adding device (analysis) is described. As can be seen from the graphs, the maximum yarn tension  $x_1=400$  high, is achieved when the yarn winding speed is  $x_2=500$  m/min and the tension washer weight is  $x_3= 20.1$  grams.

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## ASSESSMENT OF THE TECHNICAL CONDITION OF THE WEIGHT CHECKING WAGON TYPE 640-VPV-271

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### Abstract:

**Objective.** When carrying out strength calculations of the metal structure of a weighing wagon, it is necessary to take the wall thickness into account, taking into account its reduction by the value of the average wear value. Thus, it is necessary to subtract the average amount of wear from the value of the size of the thickness of the sheets of elements. In this way, it will be possible to determine whether the design of the weighing wagon with existing wear will withstand the loads required by the standards.

**Methods.** The study was conducted using two different methods.

Visual method. By examining the analysis of the technical condition of the metal structure of the scales, the faults that could affect their service life were identified. Experimental method. To compare them with the normative values and to take them into account when conducting strength studies, the values of the magnitude of the impact on the elements of the metal structure of the scales were determined.

**Results.** Thus, when calculating the metal structure of a weighing car, the wall thickness be taken taking into account its decrease by the average wear value to determine whether the strength of the wagon structure complies with the required standards.

**Conclusion.** When carrying out strength calculations of the metal structure of a weighing wagon, it is necessary to take the wall thickness into account, taking into account its reduction by the value of the average wear value. Thus, it is necessary to subtract the average amount of wear from the value of the size of the thickness of the sheets of elements. In this way, it will be possible to determine whether the design of the weighing wagon with existing wear will withstand the loads required by the standards.

**Keywords:** railway, six-axle semi-wagon, freight wagon, longitudinal beam, pivot beam, end beam.

**Introduction.** One of the conditions for the gradual development of railway transport in the Republic of Uzbekistan is to replenish the fleet of domestic wagons with modern wagons manufactured in accordance with world standards, to extend their service life in order to optimize the operation of existing wagons [1-3].

Wagons for various purposes make up the wagon fleet, which is one of the most important parts of the rolling stock of the railway. Wagons of various types are used to transport goods and passengers.

For the implementation of the transportation process, UTY JSC has a fleet of freight wagons in the amount of 20.28 thousand freight wagons, including insulated wagons. The fleet of freight

wagons includes universal and specialized wagons.

The volume of work on the dispatch (loading) of goods in tons is determined on the basis of applications from shippers [4-6]. To date, accurate measurement of the mass of rolling stock using railway scales located at the stations is a very important task. In particular, inaccurate measurement of the weight of the rolling stock by scales adversely affects the following important aspects of the organization of the safety of cargo transportation: 1-travel documents; 2-factors of the economic component; 3-control of the load falling on the rails from each wheel pair; 4-intensity of wear of rails, etc.

To date, the country's railways have weight checking wagons designed to periodically check the accuracy of measurements of railway scales located at stations.

These wagons, according to the instructions, are checked 4 times a year with the wagons being checked, designed to check the scales located at the stations. After successfully passing the test by the weighing wagon, a special certificate is assigned to the railway scales [7].

The technical condition of the metal structure of the wagon of the type 640-VPV-271 of Bukhara regional railway junction, designed to check the railway scales, which perform such an important function, was analyzed.

In order to compare them with the normative parameters of the analysis and to take them into account when conducting strength studies, the values of the magnitude of the impact on the elements of the metal structure of the scales were determined.

The weighing wagon model 640-VPV-271, located at Bukhara regional railway junction, was built in 1965. The date of the last depot repair was April 28, 2013. The weight of the wagon is 123 tons.

Previously, before determining the wear values of body elements of weighing wagons, schemes of measurement sites were drawn up, shown in Figures (1-4).

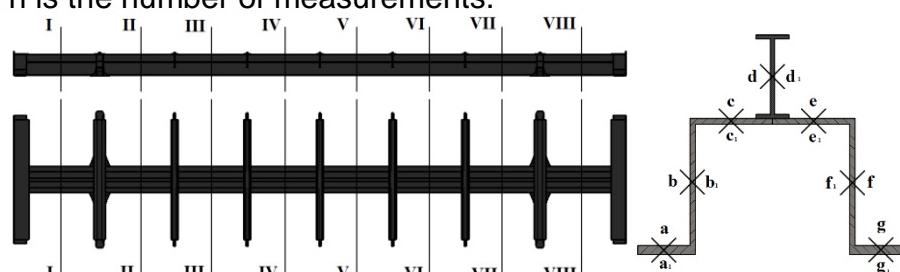
A survey of the technical condition of the main bearing elements and structural parameters of the body of this weighing wagon was carried out [8-9]. The measurement results are shown in graphs (2-5).

**Methods.** The studies were carried out using visual and experimental methods.

Based on the results of wear thickness measurements  $h^i$ , the value of the average thickness  $h_{cp}^i$  is calculated taking into account the tolerance " $\delta=0.2$  mm" for cleaning, which is determined by the formula:

$$h_{cp}^i = \frac{1}{n} \sum_i^n h^i - 0,2$$

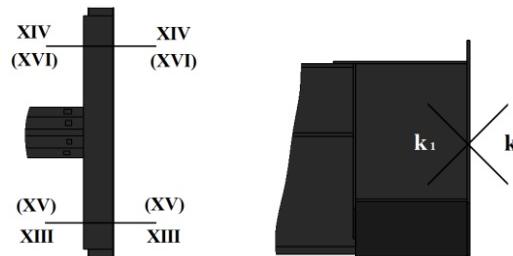
where  $n$  is the number of measurements.



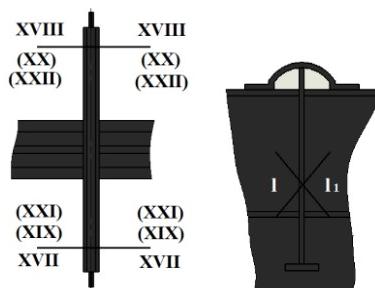
**Figure 1. Scheme of measuring the wear thickness of sheets on the center beam of the frame of the weighing wagon 640-VPV-271**



**Figure 2. Scheme of measuring the wear thickness of sheets on the pivot beam of the frame of the weighing wagon 640-VPV-271**



**Figure 3. Scheme of measuring the wear thickness of sheets on the end beam of the frame of the weighing wagon 640-VPV-271**



**Figure 4. Scheme of measuring the wear thickness of sheets on the longitudinal beam of the frame of the weighing wagon 640-VPV-271**

Table 1  
**The results of measuring the thickness of wear sheets on the center beam of the frame of the weighing car**

№	Section	Measurement values of the wear thicknesses of the elements of the pivot beam of the body frame, mm													
		a	a <sub>1</sub>	b	b <sub>1</sub>	c	c <sub>1</sub>	d	d <sub>1</sub>	e	e <sub>1</sub>	f	f <sub>1</sub>	g	g <sub>1</sub>
1.	I-I	0,61	0,56	0,63	0,26	0,6	0,65	0,32	0,33	0,56	0,63	0,52	0,43	0,38	0,34
2.	II-II	0,58	0,61	0,57	0,43	0,38	0,47	0,28	0,4	0,45	0,66	0,48	0,52	0,43	0,38
3.	III-III	0,53	0,49	0,63	0,37	0,57	0,63	0,61	0,37	0,58	0,42	0,51	0,41	0,36	0,42
4.	IV-IV	0,62	0,55	0,59	0,68	0,54	0,26	0,33	0,67	0,49	0,39	0,43	0,37	0,71	0,35
5.	V-V	0,46	0,44	0,61	0,35	0,55	0,51	0,48	0,26	0,57	0,67	0,45	0,47	0,36	0,29
6.	VI-VI	0,38	0,57	0,59	0,23	0,63	0,38	0,53	0,35	0,46	0,65	0,34	0,47	0,42	0,62
7.	VII-VII	0,64	0,55	0,53	0,58	0,52	0,68	0,36	0,32	0,62	0,63	0,48	0,36	0,41	0,54
8.	VIII-VIII	0,47	0,42	0,57	0,29	0,48	0,65	0,41	0,47	0,52	0,59	0,42	0,52	0,37	0,37
<i>h<sup>i</sup><sub>cp</sub></i>		0,77													

Table 2  
**The results of measuring the thickness of wear sheets on the pivot beam of the frame of the weighing car**

№	Section	Measurement values of the wear thicknesses of the elements of the pivot beam of the body frame, mm			
		h	h <sub>1</sub>	i	i <sub>1</sub>
1.	IX-IX	0,32	0,23	0,34	0,32
2.	X-X	0,37	0,25	0,33	0,35
3.	XI-XI	0,42	0,22	0,36	0,27
4.	XII-XII	0,34	0,27	0,35	0,31
<i>h<sup>i</sup><sub>cp</sub></i>		0,43			

Table 3

**The results of measuring the thickness of the sheets on the end beam of the frame of the weighing car**

№	Section	Measurement values of the wear thicknesses of the elements of the end beam of the body frame, mm	
		k	k <sub>1</sub>
1.	XIII-XIII	0,65	0,58
2.	XIV-XIV	0,58	0,45
3.	XV-XV	0,54	0,58
4.	XVI-XVI	0,66	0,51
<i>h<sub>cp</sub></i>		0,94	

Table 4

**The results of measuring the thickness of wear sheets on the longitudinal beam of the frame of the weighing car**

№	Сечение	Значения измерений толщин износов элементов продольной балки рамы кузова, мм	
		I	I <sub>1</sub>
1.	XVII-XVII	0,32	0,82
2.	XVIII-XVIII	0,74	0,56
3.	XIX-XIX	0,36	0,65
4.	XX-XX	0,28	0,43
5.	XXI-XXI	0,35	0,37
6.	XXII-XXII	0,63	0,43
<i>h<sub>cp</sub></i>		0,79	

**Results and Discussion.** From the above obtained data of the five examined wagons, we determine the average wear of the sheets for the elements of the metal structures of the weighing wagon according to the formula [10]:

$$h_{cp} = \frac{1}{n} \sum_i^n h_{cp}^i.$$

The results of calculations of the average wear of sheets are summarized in table 5.

Table 5

**Results of average wear thicknesses according to the elements of the weighing wagon 640-VPV-271**

№	Wagon model	Center beam	Pivot beam	End beam	Longitudinal beam
1	640-VPV-271	0,77	0,43	0,94	0,79

**Conclusion.** When carrying out strength calculations of the metal structure of a weighing wagon, it is necessary to take the wall thickness into account, taking into account its reduction by the value of the average wear value. Thus, it is necessary to subtract the average amount of wear

from the value of the size of the thickness of the sheets of elements. In this way, it will be possible to determine whether the design of the weighing wagon with existing wear will withstand the loads required by the standards.

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## ADVANCED PEDAGOGICAL TECHNOLOGIES IN EDUCATION

# PROGRAMMING AS ONE OF THE MAIN APPROACHES IN THE DEVELOPMENT OF CHILDREN'S KOMPUTATIONAL THINKING

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### Abstract:

**Objective.** Digital technologies are developing so quickly that sometimes you don't even have time to grasp the essence of these technologies. Some "lighthouse" companies are rapidly introducing cyber-physical systems and artificial intelligence into their production in order to maintain their place on the world stage. In such a world, specialists are now needed who not only actively use these technologies, but also develop them. And how to prepare the growing generation for such a world where the integration of various scientific disciplines and discoveries is proceeding at a rapid pace, and where professions disappear en masse and new ones appear, which to a large extent require programming skills. All over the world they are discussing what skills and competencies we should equip the younger generation so that in the future they can calmly rule the world. Computational thinking is recognized as a necessary competence and skill set for the 21st century. Research shows that programming is one of the approaches to shaping and developing the computational thinking of adults and children.

**Methods.** Today they are trying to teach programming at all levels of the education system, starting with preschool. Two approaches are known, teaching basic programming skills, constructionism and fundamentalization of programming, and two strategies of unplugged and connected classes.

**Results.** The analysis of the tools used in the development of computer thinking of young children is made and is given in the form of a column.

**Conclusion.** The strategy unplugged is more suitable for the development of computer thinking in our country

**Keywords:** Technologies of the fourth industrial revolution, cognitive skills, socio-emotional skills, technical skills, computational thinking, unplugged, programming.

**Introduction.** The rapid development of information technology is changing our lives, views and worldview. We stand in an era where digital technologies are reinventing artificial intelligence and cyber-physical systems, technologies of the fourth industrial revolution. With a rapid pace of development and spread, this revolution has attracted an increasing harmonization and integration of various scientific disciplines and discoveries. So what skills and competencies should we equip our children with so that they can find their place in such a world where transformations take place almost daily. When we stand still in the previous third one [1].

The World Bank, in its 2018 report, cited the skills that modern people need: cognitive, socio-emotional, and technical skills. Cognitive skills are the ability to understand complex problems, adapt to the

environment, learn from experience, cleverly overcome obstacles, and perform various reasoning. Cognitive skills are the foundations of other skills development and personal and professional development. These can be categorized into basic skills, which include basic literacy, numeracy, critical thinking, problem solving, and higher-order skills [2]. First, basic cognitive skills are formed, and on the basis of these skills, skills of a higher order are formed in the future.

Socio-emotional skills are the ability to work in a team, work on yourself, learn constantly, strive to be the first.

Technical skills are the knowledge, experience and interactions required by an employee in the workplace.

Cognitive and socially emotional skills complement each other and are considered essential skills for the 21st century. Early childhood is the optimal

period for their formation and strengthening occurs more in adulthood. An analysis of many foreign sources shows that the composite skills of cognitive and socially emotional skills like creative, critical thinking, problem solving, teamwork, learning are basic skills of computational competence thinking and activities based on it reinforce these skills [3-6].

Computational thinking is the cognitive percentage obtained during the contact of humanity with computing and digital technology [7] and has now become the main interests of specialists in many fields, especially programmers, teachers and psychologists. In fact, this skill was known from the 50s and 60s of the XX century as "algorithmic thinking" and from the 80s and 90s, "procedural thinking", introduced by S.Papert. Computational thinking has attracted the attention of scientists after J.Wing in 2006 introduced the term to science and described it as a fundamental skill for everyone, not just computer scientists. In her opinion, to reading, writing and arithmetic, we must add computational thinking to the analytical ability of every child. A study of the sources suggests that computational thinking is a broader concept than algorithmic and procedural thinking. Since then, many researchers study this term, give their definition and describe its components [4], but still does not have a specific definition and its components have not been strictly established. Let us give the definition of J. Wing: Computational thinking is the thought processes associated with the formulation of a problem and the expression of its solution (solutions) in such a way that a computer-man or a machine-can effectively perform [8]. By analyzing the sources, it can be seen that abstraction, decomposition, algorithmic thinking, automation and generalization are the most used components of computational thinking in the literatures. The evolution of computational thinking has occurred with the development of computer technology and information technology.

Computational thinking has influenced other disciplines. Computational biology is changing the thinking of biologists, the theory of computational games is changing the thinking of economists, nanocomputers, as chemists think and quantum computing, as physicists think [3].

There are scientific computational thinking, given as allowing to consider the emerging psychological structure as a new ability with its own essence, which must be specially developed and evaluated [9]. Scientists do not seek to establish the exact definition of orienting the components and components, they work on the development of teaching methods in classrooms, studying the impact of computational thinking on the academic performance of students and solving the problems of assessing this skill. All definitions are a general tendency to focus on the cognitive actions and processes of people. Accordingly actions based on computational thinking, mainly intended to improve cognitive skills to support learning processes [3].

Many works devoted to computational thinking show that one of the approaches to the development of this skill is programming [10, 11]. Scientists around the world see programming as a solution to problems in educating highly qualified specialists and programmers in the digital world and pay great attention to studying the impact of programming on the intellectual abilities of people. By creating a program, we force the computer to think, and of course this process affects our cognitive processes.

Studies have shown that teaching programming develops students' skills in problem solving [12], critical thinking [13], creative thinking [14], algorithmic thinking [15, 16], reflective thinking [17] and computational thinking [18].

Back in 1981, the metaphor "Programming is the second literacy!" uttered by academician A. P. Ershov has not lost its relevance, it can be said that it

has regained its significance anew. He paid attention to the fact that programming as a mechanism for the transition from knowledge to action, an approach to the formation of human executive mechanisms, the expression of a person's organic ability, that is ability, prepared by the organization of his nervous system and inherent in man in all his social functions [19]. We can say that the construction and principle of operation of a computer are similar to a person. The process of collecting, processing and storing information, the tools involved in this process are almost the same. The main systems such as the musculoskeletal system and the nervous system are compared with the technical (hardware) and software of a computer, as well as the work of the central control apparatus, the brain and the central processor. The human brain controls the musculoskeletal system with the help of the nervous system, and the central processor controls the hardware with the help of software. And the process of solving the problem is also the same. When solving or performing a specific task, a person goes through some stages of creating programming such as design, algorithm, debugging and analysis [20]. Therefore, curriculum courses have a positive effect on the thinking processes of the teacher.

In addition, research shows that by 2030, over 57 professions are diminished and 186 new ones will appear. These professions are listed in the Atlas of New Professions. Atlas is an almanac of promising industries and professions for the next 15-20 years. It helps you understand which industries will actively develop, how new technologies, products, management practices will be born in them, and which new specialists will be required by employers [21]. Analyzing the research of the Atlas of New Professions, it can be concluded that 60% of the professions of the future have an average supra-professional skills and IT programming skills is in demand [22].

Based on the above problems, the ministries of education of many countries are considering the tasks of restructuring the system of education [23], they began to update their curricula, which is especially for the future[5, p.30].

At present, many foreign countries have begun to implement the framework programming into compulsory education starting in primary school. And even there is a tendency all over the world to introduce basic elements programming in preschool education. Young children are taught basic programming skills. As we know from research, training takes place in two approaches, the first approach is constructionism - the philosophy of learning developed by Seymour Papert on the basis of constructivism. Where ideas are formed and transformed in different contexts and where children learn by creating their own artifacts, whether it's product design, building a sand castle or writing a computer program. And the second approach to the idea of "fundamentalization of programming", justified by A.P. Ershov, where special attention is paid to the development of thinking, especially algorithmic, spontaneously and unconsciously, without imposing new skills and knowledge that are not peculiar to children.

The basic programming course begins with basics of algorithmization and algorithmization has two aspects: developmental and programming. The developmental aspect is aimed at the development of algorithmic thinking and programmer with an introduction to a specific programming language. The development of algorithmic thinking, a key skill of computational thinking, is carried out in classrooms in two strategies, unplugged and connected to a computer [9].

**Methods.** A lesson disconnected from a computer can be considered an initial and complementary stage of a lesson, where tasks are solved using a computer, this strategy itself as a separate strategy cannot act, at some stage it gives

its place to the second strategy. This strategy is useful because it solves the problem of inaccessibility of technical software, limiting the time of work on the computer by sanitary rules and regulations, and supporting the physical activity of students. In this strategy, classes can be

carried out in a playful way, and also practical tasks and in the form of tasks, puzzles, playing schemes and cards, robotic systems, video presentations, shows and even classes can be held outdoors [26].

The tools that are used in the classroom can be divided into the following types:

1. Funds disconnected from the computer;
2. Digital and programming toys or robotic complexes (physical devices);
3. Visual Programming Environment(VBA);
4. Computer games educational programming.

Since cognitive skills are formed from childhood, these skills can be formed and developed by focusing classes on programming. Let's consider the tools that are currently used in young children of programming. (see Table 1.).

Table 1.

#### Learning programming tools for young children

No	Name	Type	Approach	Issue	Developer	Age
1.	Pictomir	Game	Blocky (without text.)	2014	Research Institute of RAS	4+
2.	Bee-bot app	Game	Blocky(textless)	2012	TTS Group	4+
3.	Bee-bot	Physical.Direct	Input Device	2008	TTS Group	4+
4.	Scratch Jr	VPE	Blocky(textless)	2014	DevTech Lab MIT Media Lab	5-7
5.	LightBot Jr	Game	Blocky(textless)	2014	SpriteBox LLC	4-8
6.	Box Island	Game	Blocky(textless)	2015	Radiant Games	6+
7.	KIBO	Physical.device	Blocky(textless)	2017	KinderLabs Robotic	4+
8.	Dash and Dot	Physical.device / game/VPE	Blocky(textless)	2016	Wonder Workshop	5-11
9.	Code.org	Web Game	Blocky (partial text) and with text	2013	Code.org	5+
10.	Kodable	Game	Blocky (textless)	2012	SurfScore	4-11
11.	Robot Turtles	Board Game	Blocky(textless)	2014	ThinkFun	3-8
12.	Matatalab	Physical device	Blocky (textless)	2017	Matatalab	3+
13.	Cubetto	Physical device	Blocky (textless)	2013	Primo Toys	3+
14.	Code-a-Pillar Twist	Physical device	Blocky (textless)	2016	Fisher-Price	3-6

The use of digital and programming toys or robotic complexes solves the problem with the lack of technical and software tools, but requires knowledge and preparation for classes from the teacher. Of course, in the other two cases, knowledge and training in working with computers are also required, more effort and skill are

required here to interest children in the lesson [25].

**Results.** In the classes of the second strategy, tasks are solved using a computer, programming is taught using online and offline tools. These can be ready-made platforms with lessons, or games, where there are programming elements, as well as free environments

where you can independently create games, cartoons and postcards [26]. There are many games and applications that teach the basics of programming, the development of logical, algorithmic and generative thinking, such as CodeMonkey, Kodable, LightBot, SpriteBox, Cargo-Bot, Robozelle, Bee-Bot, PiktoMir, etc.

The emergence of block-visual programming environments made programming more funny, understandable and accessible for every ages starting even for preschool children. Programs such as Scratch, Google Blockly, Alice, Hopscotch, Snap, Gamefroot, Tynker for schoolchildren and preschool children Scratch JN teaches programming skills from childhood. The visual programming environment can serve as the initial stage

of text-based programming and a patch for programming more levels.

**Conclusion.** Today, teaching children the basics of programming is based on the integration of two approaches, creating artifacts can achieve the development of computational thinking, a necessary skill of the XXI century. Skills development can lead to structural transformation and economic growth, especially in the digital age, and make countries more competitive in the digital world.

In our country, where the computerization of education is not fully covered, it is possible to begin the development of computer thinking with a strategy disconnected from the computer, with the help of board games and digital toys or robotic complexes.

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## DEVELOPING ACTIVITIES, THE ACADEMY OF PUBLIC ADMINISTRATION UNDER PRESIDENT OF THE REPUBLIC OF UZBEKISTAN

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The article is devoted to the historical significance of the establishment the Academy of Public Administration under the President of the Republic of Uzbekistan and its role in the training of senior personnel in the state and Public Administration. During the years of independence, reforms aimed at developing the activities of the Academy, the impact of training and the results achieved in international cooperation were analyzed.

**Keywords:** Academy of Public Administration, Learners, retraining and qualification courses, faculty and branches, international cooperation.

Large-scale reforms are carried out in the Republic aimed at democratization of state power and management, liberalization of Economy, Development of free civil society. Ensuring the consistency and effectiveness of the reforms directly depends on the leadership in the management system, during their training it is important to increase their potential, raise spiritual and moral consciousness, and improve the system of retraining continuously.

The selection, training, retraining and professional development of high-potential, politically and spiritually mature leader personnel, as well as the appointment of suitable positions are of particular importance in the effective implementation of the strategic goals of the country. Today, the state Academy of management under the president of the Republic of Uzbekistan is the leading institution in the Republic in carrying out such tasks.

After gaining independence in the country, the totalitarian system, which reigned on the basis of single-party rule, went bankrupt, and in its place efforts began to restore civil society based on Democratic demands. Of course, in every state that aims to formulate a new system, there will be problems with regard to the selection and training of potential personnel. Because the organizational forms of Management in the old system and the system of manpower training have

produced inconsistency in the achievement of the goals in the new system.

The Academy of state and public construction under the president of the Republic of Uzbekistan was established on the initiative of I.Karimov, the first president of the Republic of Uzbekistan with the aim of selection, training and retraining leader personnel on the basis of new technologies and methods, who can eliminate these problems, have high-qualified, modern knowledge, and who are initiative, aspiring to innovations, and understand the fundamental essence of new reforms.

New structures that were not during the reign of the former Union for the training of leadership personnel were established in the Academy. Scientific research was carried out on the adaptation of the system of selection and retraining of prospective personnel to the requirements of a new state and a new society. The audience was taught aspects of entering into an effective relationship with the staff, improving the systematic solution of the problems of the citizens. There is also an understanding of modern methods of training, adoption and implementation of managerial decision making projects of management personnel.

When the academy was established, 2 faculties (state and society building, principles and principles of market economy), 12 faculties were functioning. In the 1995-1996 academic year, 72 listeners

were accepted, and in the following academic years this figure reached 140 people.

The Faculty of "state relations and foreign economic relations" was established in order to radically improve and retrain the political and professional training of the senior staff of the ministries, departments, authorities, specialists of public and economic structures participating in the field of Foreign Relations. The Department of "state relations" of this faculty – 20 and the Department of "foreign economic relations" – 20 listeners were determined to be accepted on the recommendations of the ministries of Foreign Affairs and foreign economic relations of the Republic of Uzbekistan. In addition, the tasks of deepening and coordination of scientific research on the prospects of development of foreign political and foreign economic relations of the Republic of Uzbekistan were assigned.

In connection with the establishment of the new faculty, the names of some departments were changed and new ones were created. ("Foreign policy and diplomacy", "world economy and modern international economic relations", "international law, international financial institutions", "diplomacy and consular service")

Efforts made in the field of effective training and professional development of leadership personnel in the academy were focused on the development of professional activity of the audience. In particular, they were taught ways to formulate the skills of making the right decision under any circumstances, methods of protecting the interests of the state, society and citizens, and ways of ensuring the stability of society. The audience was informed about the comprehensive development of the country and the aspects of ensuring the peace of the people.

Particular attention was paid to the formation of aspects of the solution of

socio-economic, political, ideological complex problems that arise during the transition period, especially in the listeners. Also, methods of analyzing the general situation in the construction of state and society, relations between states and nationalities were taught.

Measures were taken to coordinate the training and qualification system with the modern requirements. The system of Educational Sciences introduced new educational sciences on the areas of Public Administration, the construction of society, ensuring national interests and security, management qualification, preparation for the effective management of political, social, economic processes. In particular, instead of repeating the disciplines taught in higher educational institutions, such disciplines as "National idea and responsibility of the leader", "national interests and activities of the leader", "Political Management", "political technology", "Akmeology", "psychology of Management", "sociology of Management", "Information Technology in management", "culture of management and spirituality of the leader" were introduced in new directions that meet the modern requirements of management and leadership studies.

The structure of the faculties and departments has been changed and, in contrast to higher educational institutions, such units as "society building, national idea and national interests", "Sociology and Psychology of Management", "Culture of Spirituality and management", "Modern Management", "Financial Management", "Information Technologies Of Management" have been established.

The Faculty of "Improving leadership skills and retraining leader" was established in 2006 with the aim of keeping the students informed of modern practical experience. At the same time, the "Department of improvement of qualifications" and the "Department of methodology of retraining and professional development of leader personnel" were

established, in 2006-2007 almost 2000 heads of various fields improved their skills in this faculty. A seminar on the topic "methodological problems of training and retraining of leader personnel in the conditions of democratization and modernization of public life" was organized regularly.

The basis of psychodiagnostic tests, which clearly demonstrate the personal characteristics necessary for the selection of a particular leader for a higher position,

was created; on the basis of which the study of the social and personal characteristics of a particular personnel developed a methodology for drawing up his professional program. In order to create the necessary conditions for further improvement of the professionalism of managers, a methodological base and training programs of retraining courses were designed for 1 Week, 10 days, 1 month and 3 months.

Table 1

**Information on administrative staff trained at the Academy of State and Social Construction under the President of the Republic of Uzbekistan<sup>i</sup>**

<b>Nº</b>	<b>academic year</b>	<b>Duration of study</b>	<b>graduates</b>
1	1995-1997	10 month	169
2	1997-2007	10-12,5 month	1366
3	2007-2011	10-10,5 month	644
4	2011-2012	8 month	186
<b>total</b>			<b>2365</b>

By the decree of the president of the Republic of Uzbekistan on April 10, 2012, the Academy of State and Public Construction under the President of the Republic of Uzbekistan has been reorganized as the Academy of Public Administration under the President of the Republic of Uzbekistan. In accordance with this decree, the Academy's activities were improved and the 2 year long master's degree program in the specialties of Master of Public Administration (MPSM) and Master in Public Sector Management (MPSM) started on the basis of international standards.

On August 20, 2015, the decree of the president of the Republic of Uzbekistan "On Measures to Improve the Activities of the Academy of Public Administration under the President of the Republic of Uzbekistan" was adopted, on the basis of which measures were taken to organize the activities of the Academy in educational, methodical, scientific research and information and analytical directions. In the Academy the masters began to be trained in three specialties: management in the

field of Economics, Management in the social sphere, as well as regional management. Particular attention was paid to the formation of such qualities as free use of information and Communication Technologies, good knowledge of foreign languages, understanding the purpose and essence of reforms, understanding the strategy of national development, analysis, psychological stability, constant work on oneself, strict adherence to the rules of healthy living and the ethics of the leader. Attention was paid to the development of analytical thinking in the audience, the formation of practical skills of decision-making and strategic planning in complex conditions, the qualities of initiative and leadership.

The requirements for the candidates for the master's degree and the changes in the admission processes have been introduced, and the age of the candidates has been determined to be under 35 years (previously 40 years), they should have at least 2 years (previously 3 years) work experience in the system of state bodies as a superintendent. The requirements for

candidates to know one of the foreign languages, especially the English language, have been increased, along with the candidates passing the test, the exams in 3 directions and the final interview were held. The knowledge and skills of the audience were evaluated during the academic year on the basis of tests, interviews, conclusions.

Decree of the president of the Republic of Uzbekistan "On measures for the further development of the system of training, retraining and professional development of managerial personnel in the state Academy of Management under the President of the Republic of Uzbekistan" with the purpose of eliminating the existing shortcomings and problems in the system of training of leaders, as well as introducing up-to-date technologies and in order to ensure reinforcement of it the decree of the Cabinet of Ministers were adopted. According to this decree the main working activities and tasks of the Academy and the processes of Personnel Training were reformed. Specific tasks were set for the organization of Public Administration, the creation of legal bases and modern methods of management. State educational standards for Master's specialties and retraining courses in the field of management personnel training have been developed.

Today, the Academy has become an educational institution and a scientific center capable of responding to national and world conditions; currently 330 listeners are taught by 36 professors and teachers (30 of them have scientific degrees) from Modern Management Science. The Academy consists of 2 faculties, 9 departments, 9 administrative departments and centers.

In order to study the problems of young people in the Republic, to develop scientifically-based recommendations for solving these problems, to form a database on prospective young personnel in the territory, to create a monitoring system for their professional development, and to

carry out scientific research in this regard, the Institute for Studying the Problems of Young People and Training Prospective Personnel was established at the Academy. This institution, in coordination with the Academy of Public Administration under the president of the Republic of Uzbekistan and the Youth Union of Uzbekistan, organizes retraining and professional development courses for up to 4 months and up to 1 month for retraining prospective young personnel of state authorities, state and economic management bodies, and public organizations.

At present, the institute is carrying out effective work on selection, retraining and professional development of young prospective personnel. Over the past period, 162 young people have been trained in the 4-month retraining courses of the Institute and 55 of them have been recognized as worthy of the high positions of Ministries, Departments, Organizations and local authorities.

By the decree of the president of the Republic of Uzbekistan in order to improve the quality of professional development of management personnel in the areas and to create favorable conditions for the audience in every way, regional branches of the Academy of Public Administration under the president of the Republic of Uzbekistan and the Ministry of Higher and secondary special education were established in Gulistan, Karshi, Samarkand, Urgench and Fergana. The establishment of regional branches served to elevate the work in this regard to a new level and regularly and systematically improve the skills of management personnel.

The training sessions in the regional branches are managed by means of video-conferencing; the lessons are conducted by the Academy of Public Administration, leading professors and teachers of higher educational institutions of the regions, as well as experienced specialists of ministries and departments.

In the 2018/2019 academic year, 4176 grants were allocated to these regional branches on the basis of local government bodies, territorial structures of state and economic management bodies, as well as quotas on the basis of 1680 contracts for the qualification of management personnel of non-profit and other organizations. According to April 2019, 7175 heads and civil servants improved their qualifications in the Academy and its branches.

In order to raise the level of personnel provision in the state and economic management bodies from the 2019/2020 academic year:

- implementation of training of management personnel on the basis of a grant and payment-contract, one-year leave from production and two-year master's degree without separation from production, on educational programs;

- admission to the master's and retraining courses was determined only on the basis of the primary selection of candidates among the persons recommended by the state authorities and administrative bodies, state organizations, economic management bodies and non-profit organizations of the Republic in territories, and subsequently by conducting tests and interviews at the Academy. The conduct of the initial stage of the entrance tests in places serves to increase the quality of the selection from the second side, if the first one increases the chances of the participants in the competition. The audience was determined to prepare only on the specialty "Public Administration".

International cooperation is one of the priorities of the Academy, which currently has established cooperation with more than 30 international and regional organizations, foreign universities.

In this regard, highly qualified foreign specialists in the field of public administration are involved in the organization and conduct of educational,

scientific and methodological work. Academic exchanges with leading foreign educational institutions and centers have been established in order to study advanced foreign practice. In particular, in 2019 108 professors, teachers and employees of the Academy, 159 listeners were sent abroad for internship. 73 leading experts from abroad visited the Academy and gave lectures and master classes in the areas of "State and community management system", "Strategic planning in public administration", "Economic development of territories", "Management of personal in public service" and "Innovation management".

In conclusion, it should be noted that the need for potential personnel meeting modern requirements in various spheres and sectors of Uzbekistan, which is increasing. There is an increasing need for training, retraining and professional development of management personnel of state and local bodies, HR (human resource) specialists as competitive personnel based on the experience of advanced foreign countries and the introduction of innovative technologies into practice in our country.

Therefore, the issue of improving the activities of the Academy of Public Administration under the President of the Republic of Uzbekistan, its development in accordance with modern requirements and the introduction of new technologies into the training system remains relevant. At the same time, it is necessary to reduce the regulatory requirements for candidates, increase admission quotas, and identify modern and promising areas of study. Videos showing the results achieved by graduates of the Academy should be widely covered in the media. This will increase the flow of candidates in the admission process, creating a strong competitive environment among potential candidates.

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# BLOCK DIAGRAM AND MATHEMATICAL MODEL OF AN INVARIANT SYSTEM

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**Abstract.** Recently, one of the modern directions of the theory of control, the theory of construction of state monitors of linear and nonlinear dynamic systems has significantly developed [2, 4, 10, 15]. The approach based on the expansion of the system dynamics based on the information of the input and output values due to the construction of a special dynamic system observer whose state converges quickly enough to the initial state of the system over time and the function of the state observer on the output, and the input of the initial system output variables and dynamic feedback can be applied spread out. In this case, the state observer at an arbitrary instant of time is considered as an estimate of the state of the system at a given instant of time [4]. Constructing an observer for a dynamic system is one of the ways to obtain an estimate of the state vector of this dynamic system. Solving such a problem can be of independent value as part of the general problem of dynamic systems control. The article considers the independence of the output value and the error signal from the input actions. In stabilization systems, it is necessary to add independence of the output value from the disturbing influence. The system is invariant with respect to the perturbing influence, if after the completion of the transient process determined by the initial conditions, the system error does not depend on this influence [12-16].

**Keywords:** automatic control system, invariance, input signal filtering, normalized polynomials, dispersion control, mathematical model, dynamic.

**Introduction.** Suppose some control object is described in operator form by an equation of the form

$$A(p)y = B_0(p)u + \sum_{k=2}^{\mu} B_k(p)f_k, \quad p = \frac{d}{dt}, \quad (1)$$

where  $y$  – output manipulated variable;  $u$  – control;  $f_k$  – disturbing influences;  $A(p)$ ;  $B_k(p)$  – polynomials with constant coefficients of degrees  $n$  and  $m_k$ , and  $m_k \leq n$ . Note that (1), in the general case, can be like an equation of a one-dimensional object, and the equation of one of the channels of the multidimensional control object, after the introduction of decomposition control [8].

The task of synthesis is to determine the order and values of all parameters of the control device described by the equation

$$R(p)y = Q_0(p)\varphi - Q_1(p)u - L(p)y + \sum_{k=2}^{\mu} Q_k(p)f_k, \quad (2)$$

where  $\varphi$  – error signal;  $g$  – impact on the main input of the system. In the general case  $g = f_0 + f_1$ ; and  $f_0$  – defining, and  $f_1$  – disturbing influence;  $f_2, \dots, f_\mu$  – measurable perturbations, attached to the object,  $\bar{\mu} \leq \mu$ ,  $R(p)$ ,  $L(p)$ ,  $Q_k(p)$  – polynomials with constant coefficients. Moreover, if the degree of the polynomial is  $r$ ,

then, according to the realizability conditions, the degree of the remaining polynomials in (2) is at most  $r$ .

Additional feedback loops defined by operators  $Q_1(p)$  and  $L(p)$  in the control device (2), are very essential in the synthesis of invariant systems. It is they that make it possible to "untie" the fulfillment of the conditions of stability and invariance. We emphasize that the expediency of finding a solution to the problem of synthesis of invariant systems in the class of multiloop systems was repeatedly noted in the works of G.V. Shchipanova and especially A.G. Ivakhnenko.

Synthesis of system (1), (2), whose mismatch  $\varepsilon = f_0 - y$  invariant in the sense of V.S. Kulebakin to some impact  $f_k$ ,  $k \in [0, \mu]$ , is carried out on the basis of the dynamic model of the latter, which can be specified in the following ways:

- by using  $K_{p f_k}$  - exposure images  $f_k [3,5]$ , i.e. a polynomial  $F_k(p)$ , which is in fact an eigenoperator of the homogeneous differential equation

$$F_k(p) f_k = 0$$

- note that this polynomial is equal to the denominator of the image  $f_k(p)$  this impact according to Laplace;
- in the form of an impact spectrum, i.e. a set of numbers  $\{\sigma_{k1}, \sigma_{k2}, \dots, \sigma_{kr_k}\}$  – poles of transformation of this influence according to Fourier or Laplace;
- equations in Cauchy form

$$\square w = F_k w_k = 0, \quad f_k = a_k^T w_k$$

Here  $w_k$  –  $r_k$  - dimensional vector of variables;  $F_k$  and  $a_k$  corresponding dimensions matrix and vector of coefficients,  $T$  – transposition operation symbol.

We emphasize that all the above forms of describing the impacts are equivalent to each other, since

$$F_k(p)p^{r_k} + \sum_{i=0}^{r_k-1} n_{ki} p^i = \prod_{i=1}^{r_k} (p - \sigma_{ki}) \det(pE - F_k). \quad (3)$$

Here  $E$  – identity matrix.

Regarding impacts  $f_k$ ,  $k \in [0, \mu]$ , the model of which in any of the specified forms is not known, it is only assumed that they are limited in absolute value.

The order and parameters of the controller (2), according to [6, 8], are determined by the closed system equation. In this case, it is convenient to write it relative to the error signal  $\varepsilon = f_0 - y$ . From equations (1) and (2) we obtain

$$H(p)\varepsilon = \sum_{k=0}^{\mu} P_k(p)f_k, \quad (4)$$

where

$$H(p) = A(p)[R(p) + Q_1(p)] + B_0(p)\bar{L}(p), \quad (5)$$

$$P_0(p) = A(p)[R(p) + Q_1(p)] + B_0(p)L(p), \quad (6)$$

$$P_1(p) = -B_0(p)Q_0(p), \quad P_k(p) = -B_k(p)[R(p) + Q_1(p)], \quad k = 1, \dots, \mu, \quad (7)$$

$$P_k(p) = -B_0(p)Q_k(p) - B_k(p)[R(p) + Q_1(p)], \quad k = 2, 3, \dots, \mu.. \quad (8)$$

Here indicated

$$\bar{L}(p) = Q_0(p) + L(p) \quad (9)$$

For greater concreteness, we also present the conditions for the invariance of control systems. According to [1, 2, 6], the error of system (4) with respect to the impact  $f_k$  will be invariant in the sense of G.V. Shchipanova, if

$$P_k(p) = 0, \quad (10)$$

but in the sense of V.S. Kulebakin, if only

$$P_k(p) = \tilde{P}_k(p)F_k(p), \quad \text{GCD} \{F_k(p), H(p)\} = 1 \quad (11)$$

Here  $\tilde{P}_k(p)$  – some polynomial in  $p$ ; GCD – greatest common divisor.

The stability conditions, taking into account the requirements for the quality of the system, we will take in the form

$$H(p) \in \Omega. \quad (12)$$

Here  $\Omega$  – a set of polynomials whose zeros are located in the region that is admissible from the point of view of the quality of the synthesized system;  $\in$  – belonging sign. Moreover, we will assume that

$$\text{GCD} \{F_k(p), B_k(p)\} = 1, \quad (13)$$

i.e. if part of the perturbation poles  $\bar{f}_k$ , applied to the object (1) coincides with the zeros of the polynomial  $P_k(p)$ , then these poles can be ignored in the polynomial  $F_k(p)$ , since the influence of the corresponding components of the perturbation  $\bar{f}_k$  will be completely suppressed by the object and without control.

In accordance with the analytical, polynomial synthesis method [5, 8], the polynomials  $H(p)$  and  $P_k(p)$ ,  $k = 0, 1, \dots, \mu$ , are assigned in accordance with the desired quality of the designed system and the conditions for the physical feasibility of the control device, and expressions (5) - (8) are considered as equations for unknown parameters of the controller (2).

In practice, this means that in order to solve the problem of synthesis of invariant automatic control systems, it is necessary to be able to assign a polynomial  $H(p)$ , so that it belongs to the multitude  $\Omega$ , and polynomials  $P_k(p)$ ,  $k = 0, 1, \dots, \mu$  in accordance with conditions (10) or (11). Then the conditions under which such assignments are possible, and equations (5) - (8) are solvable with respect to the parameters of the controller (2), will be the solvability conditions for the problem of synthesis of system (1), (2) invariant in the sense of G.V. Shchipanova or V.S. Kulebakin to one or another effect  $f_k$ ,  $k \in [0, \mu]$ .

In particular, if  $m_0 = n$ , and  $B_0(p) \in \Omega$  then assuming  $Q_1(p) = -R(p)$ ,  $L(p) \in \Omega$ ,  $\deg L(p) = \deg R(p)$  and  $Q_k(p) = 0$ ,  $k = 0, 1, \dots, \bar{\mu}$ , we obtain an absolutely invariant automatic control system to all influences  $f_k$ ,  $k \in [0, \bar{\mu}]$  except  $f_1(t)$ .

Absolute error invariance  $\varepsilon$   $f_0 - y$  system (1), (2) with respect to the perturbation  $f_1(t)$ , applied to the system at one point with the driving force  $f_0$ , achieved only when  $Q_0(p) \equiv 0$ , which is equivalent to turning off the input signal of the system. This condition is obviously impossible, and therefore there is no solution to the corresponding synthesis problem.

**Material and methods.** One of the ways to obtain high accuracy in automatic control systems is the use of invariance theory methods.

Let the linear system be represented by the following equation:

$$A(q^{-1})y(t) = B(q^{-1})u(t-k) + D(q^{-1})w(t-d), \quad (14)$$

where:  $y(t)$  – output,  $u(t)$  – input and  $w(t)$  measured perturbation.

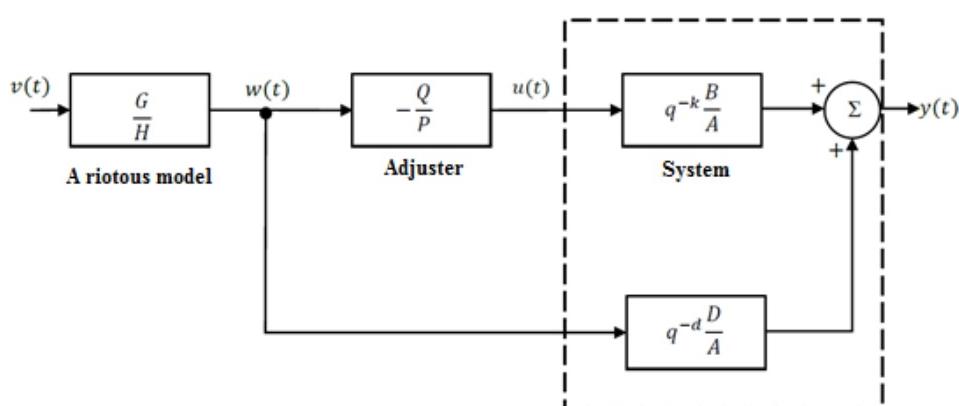
the inverse  $q^{-1}$  shift operator, the polynomials  $A, V$ , and  $D$  have zero coefficients in the large fractions.  $na$ ,  $nb$  and  $nd$  are their degrees [1].

$A(q^{-1})$  a polynomial can be normalized and a stable polynomial,  $B(q^{-1})$  and a polynomial can be unstable. Turbulence is represented using the following equivalent stochastic model

$$w(t) = \frac{G(q^{-1})}{H(q^{-1})} v(t), \quad (15)$$

where:  $N$  and  $G$  are constant and normalized polynomials.  $v(t)$  a white stationary process has zero mean and  $\Lambda_v$  variance.

The problem is to synthesize the correct coupling stable rectifier illustrated in Figure 1.



**Fig. 1. The structure of the direct communication control system**

$$u(t) = -\frac{Q(q^{-1})}{P(q^{-1})} w(t), \quad (16)$$

where  $P$  is a normative polynomial, the conditions for minimizing the quality criterion in the following form [2] .

$$J = E y(t)^2 + \rho E (\tilde{\Delta}(q^{-1}) u(t))^2. \quad (17)$$

For minimal-phase systems with sufficient delay time (  $B$  steady), the following is the case

$$u(t) = -q^{-d+k} \frac{D(q^{-1})}{B(q^{-1})} w(t)$$

described by the relationship (  $d \geq k$  ) provides ideal control with the help of correct contact ( $y(t) = 0$ ) [3-5, 7-9].

Next, we will use the following polynomials of various forms

$$D = D(z) = d_0 + d_1 z + \dots + d_{nd} z^{nd},$$

here we replace  $z$  with  $q^{-1}$ .

Interrelated polynomials :

$$D_* \stackrel{\Delta}{=} D(z^{-1}) = d_0 + d_1 z^{-1} + \dots + d_{nd} z^{-nd}.$$

Inverse polynomials :

$$\bar{D} \stackrel{\Delta}{=} z^{nd} D_* = d_0 z^{nd} + d_1 z^{nd-1} + \dots + d_{nd}.$$

$\bar{D}$   $D$  reflected around the unit radius.

If  $D$  is stable,  $\bar{D}$  it must be unstable.  $D_c$  and  $D_u$   $D$  denote the stable and unstable part of the polynomial.  $D'$  denotes the polynomial associated with the input signal estimation problem [7-9, 10-15].

We use spectral factorization

$$r\beta\beta_* = BB_* + \rho A\tilde{\Delta}\tilde{\Delta}_*A_*, \quad (18)$$

where  $\tilde{r}$  - is a positive scalar coefficient,  $\beta$  and  $-$  is a stable normalized polynomial of the following degree in  $z$

$$n\beta = \begin{cases} nb & npu \rho = 0 \\ \max \{nb, na + \deg \tilde{\Delta}\} & npu \rho > 0. \end{cases}$$

$\rho > 0$  in order to have a stable spectral factor when In a minimum dispersion control  $\rho = 0$ ,  $V$  cannot be zero around a unit radius . If these conditions are fulfilled, then (16) is a well-connected adjuster (14), (15) for a stable system, when restricting the adjuster to stability (17) ensures obtaining the global minimum value of the criterion [5], if:

1)  $R$  is determined from the following expression

$$P = \beta G, \quad (19)$$

here is  $\beta$  the constant spectral factor in (18).

2)  $Q_*(z^{-1})$  and  $L(z)$

$$\begin{aligned} nQ &= \max\{na + nh - 1, nd + ng + d - k\}, \\ nL &= \max\{n\beta, nb - d + k\} - 1. \end{aligned} \quad (20)$$

the following rank

$$z^{-d+k} BD_* G_* = r\beta Q_* + A_* H_* z L$$

is the solution of the equation.

Let us consider the stochastic equation with discrete variable expressed as follows

$$y(t) = \frac{B'(q^{-1})}{A'(q^{-1})} u(t-k) + \frac{M'(q^{-1})}{N'(q^{-1})} v(t), \quad (21)$$

the unknown  $u(t)$  input sequence is expressed as

$$u(t) = \frac{C'(q^{-1})}{D'(q^{-1})} e(t), \quad E v(t)^2 / E e(t)^2 = \rho. \quad (22)$$

All parameters of the system are assumed to be stable.

$A'$ ,  $D'$  and  $N'$  polynomials can be stable and normed,  $C'$  and  $M'$  polynomials can be stable,  $M'$ ,  $C'$  and  $B'$  polynomials can be unstable [5, 14].

$v(t)$  and  $e(t)$  sequences of white noise are assumed to be stationary with zero mean and uncorrelated. The task is to determine a stationary linear estimator for the input

$$\hat{u}(t | t-m) = \frac{Q(q^{-1})}{P(q^{-1})} y(t-m), \quad (23)$$

it minimizes the mean squared error of estimation [1, 2, 5]

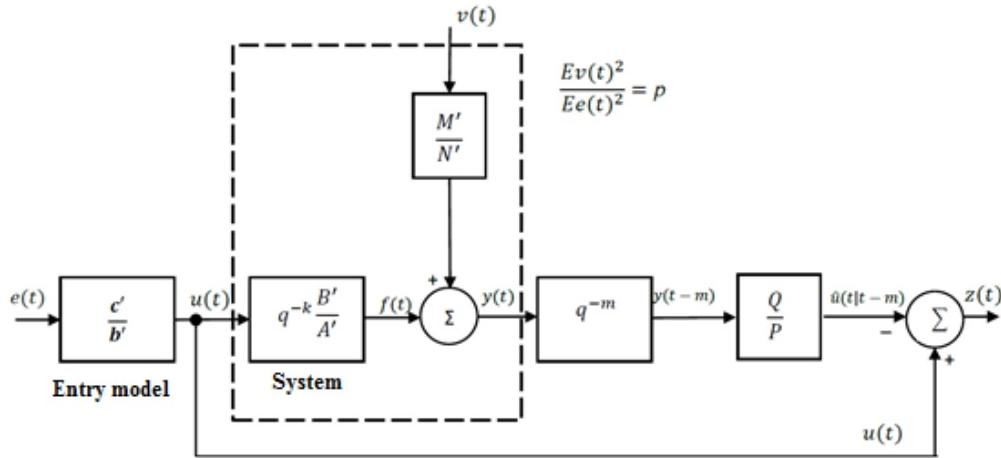
$$E z(t)^2 \stackrel{\Delta}{=} E(u(t) - \hat{u}(t | t-m))^2. \quad (24)$$

Depending on the size of  $(m > 0)_m$ , one can obtain input prediction,  $(m = 0)$  filtering, or  $(m < 0)$  fixed-delay smoothing problem.

It is known that the minimum achieved error of estimation decreases with decreasing  $m$ .

**Results and discussion.** The problem statement consists of filtering  $A' = B' = 1, k = 0$  the output (evaluation of Figure 2  $f(t)$ ) as a separate case.

minimum-phase (steady-state) systems with  $B'$  undisturbed outputs ( $\rho = 0$ )  $u - m - k$ , input recovery can be obtained using an inverse system.



**Fig. 2. The structure of the problem of evaluation of riots**

$$\hat{u}(t-k|t) = \frac{A'(q^{-1})}{B'(q^{-1})} y(t) = u(t-k).$$

Spectral factorization is required to obtain a general solution

$$r\beta'\beta'_* = C'B'N'C'_*B'_*N'_* + \rho M'A'D'M'_*A'_*D'_*, \quad (25)$$

where  $r$  is a positive scalar factor,  $\beta'(z)$  and is a constant and normative polynomial of the following degree in  $z$ :

$$n\beta' = \begin{cases} nc' + nb' + nn' & \text{azap } \rho = 0 \\ \max \{nc' + nb' + nn', nm' + na' + nd'\} & \text{azap } \rho > 0. \end{cases}$$

$\rho > 0$  in order to be stable when  $\beta'$  (25) it is necessary and sufficient to accept two segments that do not have zero common multipliers in the unit circle on the right side of [1, 5].

( $\rho = 0, N = 10$ ),  $C'$  and  $B'$  there should be no zeros around the unit radius in the absence of noise. If there is stability  $\beta'$ , (24) the estimation filter of the input signal (21), (22) ensures obtaining the global minimum value of the estimation error at the stability limits of the filter (24) for systems [2, 3, 4, 7, 12], if

$$\frac{Q}{P} = \frac{Q_1 N' A'}{\beta'}, \quad (26)$$

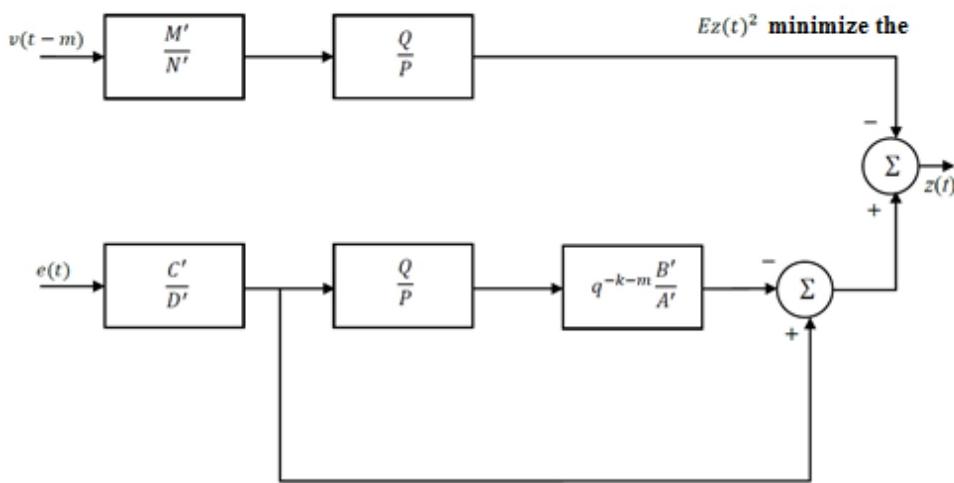
if here  $\beta'$ , the stable spectral factor derived from (25) is the following  $L(z)$

$$nQ_1 = \max \{nc' - m - k, nd' - 1\},$$

$$nL = \max \{nc' + nb' + nn' + m + k, n\beta'\} - 1. \quad (27)$$

$$\text{rank } z^{m+k} C'B'N'C_* = r\beta' Q_{l*} + D'_* z L \text{ system.}$$

In order to more clearly demonstrate the relationship between management and evaluation issues, we replace the evaluation issue presented in Figure 3 and illustrated in Figure 2.



**Fig. 3. Communication structure between management and evaluation issues**

In Figure 3, the lower channel becomes a structure in the case of a well-coupled matching control, where  $Q/P$  - corresponds to the rectifier that needs to be synthesized.

It should be noted that when  $u_1(t)$  the signal in the upper channel is not correlated with  $u(t)$  and  $y(t)$ , its dispersion  $\rho Eu(t)^2$  is determined by the expression, as well as

$$Ev(t)^2 / Ee(t)^2 = \rho.$$

Thus, criterion (22) can be written in the following form

$$Ez(t)^2 = E(y(t) + u_1(t))^2 = Ey(t)^2 + Eu_1(t)^2 = Ey(t)^2 + \rho Eu(t)^2.$$

**Conclusion.** Comparing the corresponding blocks in Figure 1 with the blocks in Figure 3 allows us to draw the following conclusion. The input evaluation problem defined by the expressions (20)-(22) can be considered as a well-connected equivalent control problem. If  $M'$  is stable,  $Q/P$  the optimal filter can be synthesized using relation (18)-(19).

The mentioned methods allow the use of different algorithms for evaluating input effects in the synthesis of invariant control systems of dynamic systems.

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## IMPROVING STUDENTS SPEAKING SKILLS IN PRACTICAL LESSONS

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**Abstract:** This article focuses on improving students' speaking skills in practical English classes. According to the results of interviews conducted in order to obtain preliminary data on students' speaking skills, it was found that students face problems in speaking due to their insufficient knowledge of the language, which in turn makes students feel insecure about speaking. . Students were not familiar with different speaking activities that facilitate speaking. They read text to convey ideas and lack strategies when speaking. To help students, task-based learning is adapted through action research in courses. 15 students in these courses participate in this study. Data is collected from pre-test to post-test to interview. Findings show that using task-based learning helps students improve their speaking skills on four dimensions: accuracy, vocabulary, fluency, and comprehension. Students succeed in completing tasks by engaging in

a variety of activities at three stages of learning: pre-task, task-cycle, and form-focus. They manage to improve their speaking skills and gain self-confidence. Students can assess their knowledge in pair and group work.

**Keywords:** pre-test, post-test, interview, speaking skills, task-cycle, form-focus, accuracy, vocabulary, fluency, comprehension.

**Introduction.** One of the most necessary skills for living in the twenty-first century is gaining the ability to know and use another language. In many areas of life, from business transactions to broadcasting television weather warnings, the demand for proficiency in a foreign language is growing. One of the most important skills to have in a foreign language is the ability to speak the language with native or non-native speakers of that language. A great number of foreign language learners most likely consider one of their primary language goals to be the ability to speak the language at a high level of proficiency. Thus, oral proficiency has become an important focus in the foreign language classroom. Learners in a foreign language classroom are primarily exposed to four different communication skills: reading, writing, listening, and speaking. Of these four skills, speaking is generally regarded as the most difficult in which to attain proficiency due to its complex nature. Though each of the four language skills can be taught in conjunction with another of the skills, it is important to look at speaking here in isolation. Speaking is considered the most important skill compared to the other three language skills: reading, listening and writing. When people speak a language, as it includes all other types of cognition, they can be called "speakers of the language" (Ur, 2012: 117). They use their linguistic knowledge and background knowledge to communicate ideas, discuss meaning, and explore ideas. They use words very skillfully and put them into appropriate sentences to create interesting conversations. As Bygate (2009) says, when we speak, we not only need to know vocabulary and grammar, but also to produce and adapt them to the situation. After the speaker acquires the knowledge

and skills to use them, he quickly makes decisions, implements them smoothly, and adjusts the conversation to self-interaction. However, acquiring knowledge and using it in speech is not always easy for EFL and ESL students. Most students have difficulties in expressing grammatically correct sentences because there are significant differences between students' native language and EFL grammar (Manurung, 2015). Students have limited opportunities to experience speaking activities in class and Hamouda (2012) from Qassim University, Saudi Arabia conducted a study on the problems students face in speaking. The results showed that due to many factors such as low English proficiency, fear of speaking in front of others, negative evaluation, shyness, lack of self-confidence and preparation, and fear of making mistakes, many students in the EFL classroom students do not want to answer their teacher. . Similarly, EFL students who do not want to speak English in Indonesia experience similar factors and cultural issues affect their learning. Students speak Bahasa Indonesia while learning English in the classroom. They become "unquestioning minds" in their interactions because they believe that the teacher never makes mistakes (Marcellino, 2008). Students do not take much initiative in learning because they prefer to do what their teacher tells them to do. A complex educational process affects students' speaking ability. During the interview to collect preliminary data on students' speaking skills for this study, the students mentioned that they are always assigned a group presentation task, which they prepare at home. In class speaking, they read texts to express ideas. They don't use strategy when they speak. Students are not familiar with the different speaking activities

that can help them speak on their own. They are embarrassed because their friends laugh at them when they talk. Their pre-test results show that students' speaking skills are considered low. Accuracy is the lowest, followed by vocabulary and comprehension. Students need to be helped to improve their speaking skills, so the researcher decides to use task-based learning. Task-based learning emphasizes learning through the use of tasks in both instructional planning and classroom instruction (Richards, 2006; 30).

**Methods.** Teaching speaking in the foreign language classroom is vital and at times, complicated.

The methodology of foreign language teaching has changed a great deal through the 20 century, and though speech has been an integral part of language teaching in many historical methods, it was recently with the idea of communicative competence that speaking with the intent of true oral communication became important again. An important consideration to teaching speaking is what teaching approaches and activities best support the development of oral communication: how to teach the necessary skills for students to accurately produce speech forms (grammatical form, vocabulary, phonological patterns), and how to also enhance speaking fluency (Bums 1998 Hadley tells us in her text that "communicative competence" arose in the 1970s and 1980s and is still an important foreign language teaching methodology today, and states that Hymes' theory of communicative competence may be defined simply as the underlying structural knowledge of language and the ability to use this knowledge in actual communication.

Communicative competence incorporates the ability of the student to posses skills not only for the form of a language, but to also be able to use the language for communicative purposes, thus making the ability to use language to communicate effectively within

different social contexts a crucial part of communicative language teaching (Bums 1997 44). As described by Canale, communicative competence consists of four major components: grammatical, sociolinguistic, discourse, and strategic competence. Grammatical competence is the degree to which the speaker knows the rules of sentence structure, vocabulary, pronunciation, and spelling and thus contributes to the speaker's fluency. Sociolinguistic competence is the extent to which the speaker can use and understand the language appropriately in various contexts such as basic conversation, describing, narrating, persuading, and things similar. Discourse competence is the ability to coherently and cohesively connect words and phrases in order to convey knowledge and ideas, such as separating ideas, showing contrast, transitioning to a new topic, and indicating cause. Strategic competence is the ability to use communication strategies to help the speaker compensate for the specific things they do not know in a conversation, such as inferring the meaning of an unknown word based on surrounding context, or asking the other speaker to speak more slowly if not understood (Hadley 2001 and Savignon 2001). Communicative language teaching integrates all four skills (reading, writing, listening, speaking) and emphasizes mainly the ability to use the language for communication purposes. The focus is put on the learner, and a diverse array of classroom activities can support the learner in learning how to use the language. The communicative curriculum, as stated by Savignon in her 2001 article "Communicative Language Teaching for the Twenty-First Century", consists of five components: Language analysis concentrates on the forms of language syntax, morphology, lexicon, and phonology through familiar drill, translation, and "workbook" exercises. Language experience focuses on the use of English for immediate communicative goals. Learner identity focuses on the

learners' attitudes and motivations concerning the second language and explores self-expression in the new language. Theater Arts examines the sociocultural rules of communication appropriateness through role-play. Beyond the Classroom looks at the real-life situations in which learners will use the language outside of classroom instruction. This curriculum is just one example of how communicative competence takes shape in the classroom. Learning focuses on negotiating meaning, using the target language to communicate authentically and meaningfully (Richards, 2006). Negotiation of meaning aims to solve communication problems (Suzuki, 2018). Task-based learning allows students to learn to use form and communication (Larsen-Freeman and Anderson, 2011; 193). Form-oriented work functions as active skills because it is designed to develop skills and knowledge that facilitate the actual communication process (Nunan, 2004: 22). Activation skills are of two types: language exercises and communicative activities. Students are expected not only to understand language functions but also to use them (Branden, 2006; 6). It aims to improve linguistic accuracy in students' speech, even if there is no communication problem between them (Suzuki, 2018). Since the concept of task-based learning is learning by doing, students are expected to experience the language by completing tasks. Proponents of task-based learning mention the types of tasks that are performed during the learning process. As Richards (2006) pointed out, pedagogical tasks and realistic tasks help students learn the language. Pedagogical tasks, for example, focus on information spaces, strategic interaction and the use of the language element (Nunan, 2004, Hossima and Tasud, 2014). However, a real-life task, such as an interview role, reflects language use outside the classroom. Pedagogical tasks are designed to activate students' speaking skills, not to train students to complete tasks (Nunan, 2004).

Willis and Willis (2007) suggest seven task types: sorting, matching, comparing, project and creative tasks, sharing personal experiences, problem solving, and listing. J. Willis (1996) says that a task is a purposeful activity for students to use language to achieve a realistic result. They use target language resources to solve problems, do puzzles, play games or share and compare experiences. Nunan (2004; 35-37) presents principles for implementing task-based learning. They are (1) scaffolding in which lessons and materials should support learning and students are not expected to produce language they have not yet learned, (2) task dependence, meaning that one task should grow throughout the lesson . (3) language processing maximizes learning opportunities and activates "organic" learning, (4). active learning, students learn best through active use of the language they are learning, (5) integration, teaching students in ways that make clear the relationships between linguistic form, communicative function, and semantic meaning should, (6) motivate students to action. from reproductive language to creative use, (7) reflection, students should be given opportunities to think about what they have learned and how well they are doing. Research has shown the benefits of using task-based learning to improve students' speaking skills. The results of a study by Namaziandost, Hashemifardnia, & Shafiee (2019) show that when students complete feedback, thinking-space, and information gaps through task-based learning compared to traditional learning then they can speak fluently. Similarly, Albino (2017) found that students could improve their speaking skills, especially in terms of grammar, after their teachers used reframing and prompting strategies in the task cycle. Focusing on form through task repetition can help students build their grammar knowledge from simple to complex forms as they receive feedback during the learning phase (Van de Guchte,

Braaksma, Rijlaarsdam, & Bimmel, 2016). The more often students participate in different tasks, the better they rate their performance (Meng and Cheng, 2010). However, more emphasis should be placed on task-based teaching in EFL classes (Elsheykh Hago Elmahdi, 2016). The teacher can adapt the tasks set by the supporters of the assignments and create activities that help the students to complete the assignments.

**Results.** Speaking is defined by Anne Burns in her 1997 book, Focus on Speaking, as "an interactive process of constructing meaning that involves producing, receiving, and processing information" (14). In addition, it is a multi-level, hierarchical skill in which an individual must form and articulate thought processes under a wide range of conditions, suggests Bygate in his 2002 article entitled "Speaking". The form of spoken language and the meaning of the utterance depend on the context in which speaking occurs. According to Florez 2003, this context may be considered the speakers themselves, their experiences, the surrounding environment, and the reasons for speaking. Speaking is always a skill that involves interaction with another person, whether the speaker is conversing with someone else or formally presenting information to listeners in a speech. Florez also states that speaking is not always predictable but is frequently "spontaneous, open-ended, and evolving" (1). Lazaraton 2001 and Grove 1999 state that speaking is the most demanding of the four language skills because of the variety of components involved. These components include things such as slang and idioms used in conversational speech, reduced forms of words and phrases, the pressure that can arise from interacting directly with another person and expressing a thought in real time, the spontaneous nature of speech, the sociolinguistics of the message, and the simultaneous demands imposed on the speaker.

**Discussion.** While speaking is a very necessary skill for daily communication between people, it is also a very complex process. Simply put, the process of speaking involves: 1) constructing a discourse plan to relay the speaker's intentions, 2) thinking through the specific message to be relayed, 3) forming the thought into grammatically correct utterances (a process that can be complicated and stressful due to the time constraints that accompany uttering a thought in the quick pace of conversation, explaining the difference between written and spoken language), 4) articulating the thought aloud using appropriate word choice for the situation and correct pronunciation, and 5) actively monitoring and correcting the spoken message (Bygate 29-32). Speakers must know how to produce specific and formulated parts of language such as grammar, pronunciation, and vocabulary, which is considered to be linguistic competence. Speakers must also understand the context in which they produce language and effectively exercise their linguistic competence when, why, and in what ways considered appropriate. This is sociolinguistic competence (Florez 1). Both of these competences are considered equally important: if a speaker lacks linguistic competence, his or her message of mixed up grammar and incorrect vocabulary may be misunderstood, and if a speaker lacks sociolinguistic competence, his or her message and its intentions may be misunderstood. Certain skills that should be addressed while instructing speaking may include using grammar structures accurately, using correct suprasegmentals in the foreign language (stress, rhythm, tone, etc), using appropriate gestures and body language, and strategies for enhancing comprehensibility, among other things (Florez). Ultimately, speakers must be able to convey their message using intelligible words and phrases, and do so in a way that is appropriate to the discourse situation. There are a variety of different situations in

which anyone who communicates orally will find himself or herself. Burns (1998) highlights these different communication genres, which include casual, polite, or formal interpersonal conversations, and factual or transactional pragmatic encounters ( 109). There are also other kinds of speech such as formal presentations. Just as there are such a wide variety of situations in which we can find ourselves speaking, there must be a variety of activity types for students learning a foreign language to practice these skills. Teachers must alert students to the different genres of speech, and be certain to practice these different oral communication genres, such as formal exchanges, conversational exchanges, and critical discourse (111). Students learning how to speak should be exposed to different practice situations involving: informal and formal conversations including telephone conversations, persuasion, arguing for or against a point, formal speeches, and all types of situations in which people talk.

**Conclusion.** In my foreign language classroom, I hope to someday successfully incorporate many of these ideas and strategies for teaching speaking. I believe that Communicative Competence is a strong and effective method to follow and I foresee my future language classroom incorporating the various components of this methodology. I also believe in the viewpoints of errors being a natural by-product of learning a foreign language and that not every error should be corrected. Improvements in students' scores indicate that students' speaking skills are improving. This fact is confirmed by the attitude of students towards the use of task-based learning. They say that doing different activities by working in pairs and groups will help you to speak English better. They can practice simple dialogues, turn taking, information gap, interview, discussion, short role play, simulation and mini-drama. Most importantly, they can assess their knowledge. A variety of learning experiences encourage students to improve their speaking skills in the future.

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## A LEXICAL-SEMANTIC STUDY OF TERMS RELATED TO AGRICULTURAL TECHNOLOGY IN UZBEK AND ENGLISH LANGUAGES

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### Abstract:

**Objective.** This study conducts a thorough Lexical-Semantic analysis of terms related to agricultural technology in both Uzbek and English languages. Utilizing a comparative approach, the research explores linguistic nuances, cultural influences, and semantic variations in the lexicons of these languages within the context of agricultural technology. By examining specialized texts and employing semantic analysis

tools, the study aims to unravel the intricate interplay between language, culture, and technological concepts.

**Methods.** The research employed a comparative analysis approach, utilizing a corpus of agricultural technology-related texts in both Uzbek and English. Specialized dictionaries, academic publications, and industry documents were examined to compile a comprehensive list of terms. Semantic analysis tools were then employed to discern the connotations and nuances associated with each term.

**Results.** The Uzbek language, with its Turkic roots, reveals a lexicon deeply intertwined with agricultural practices. Terms often reflect the region's rich agricultural history, emphasizing the significance of crops and farming techniques unique to Uzbekistan. The study identifies linguistic patterns and semantic shifts that distinguish Uzbek agricultural technology discourse. English, as a global lingua franca, showcases a diverse and dynamic lexicon in the realm of agricultural technology.

**Conclusion.** This Lexical-Semantic study provides valuable insights into the terms associated with agricultural technology in Uzbek and English. By unraveling the intricacies of language within this domain, the research contributes to a deeper understanding of how linguistic choices influence perceptions and communication in the field of agricultural technology.

**Keywords:** Lexical-Semantic, Agricultural Technology, Uzbek Language, English Language, Comparative Analysis, Semantic Variations, Cross-Cultural Communication.

**Introduction.** In the ever-evolving landscape of technological innovation, the field of agricultural technology stands as a crucial nexus where advancements intersect with the age-old practices of cultivating the land. Language, as a fundamental tool for communication and knowledge dissemination, plays a pivotal role in shaping how societies comprehend and engage with these innovations. This study embarks on a comprehensive exploration of the lexical and semantic dimensions of terms associated with agricultural technology, with a particular focus on the linguistic expressions in both Uzbek and English.

As languages are not mere vehicles for communication but carriers of cultural nuances and historical echoes, understanding the lexical choices made in the discourse surrounding agricultural technology becomes essential. The juxtaposition of Uzbek, rooted in its Turkic origins and reflective of regional agricultural practices, with English, a global lingua franca adapting to diverse cultural influences, presents a rich terrain for investigation. By scrutinizing the lexical landscape of these languages, we aim to uncover subtle variations, cultural influences, and semantic intricacies that contribute to the unique expression of agricultural technology concepts.

This research employs a comparative analysis approach, drawing from a corpus

of specialized texts, dictionaries, academic publications, and industry documents in both languages. The methodology incorporates semantic analysis tools to discern connotations, shedding light on the nuanced meanings embedded in the terminologies. Through this interdisciplinary exploration, the study endeavors to unravel how linguistic choices mirror and influence perceptions, thus providing valuable insights into the intersection of language, culture, and agricultural technology.

**Methods.** The foundation of this study lies in a diverse corpus carefully curated to represent the discourse on agricultural technology in both Uzbek and English. The corpus encompasses a spectrum of sources, including specialized dictionaries, academic publications, industry reports, and technological documents, ensuring a comprehensive coverage of terminology. A comparative analysis approach was adopted to scrutinize the lexical choices in Uzbek and English. The selected terms were systematically compared, emphasizing similarities, differences, and contextual variations. This process aimed to unveil patterns in terminology usage, providing insights into how speakers of each language navigate the landscape of agricultural technology expression.

To delve deeper into the meanings encapsulated within the identified terms,

semantic analysis tools were employed. Natural Language Processing (NLP) techniques facilitated the extraction of semantic nuances, connotations, and shifts in meaning. This analytical layer allowed for a more granular exploration of the semantic dimensions of agricultural technology terminology in both languages. Lexical patterns were extracted through meticulous examination of the corpus. Common prefixes, suffixes, and roots were identified to reveal the structural components shaping the terminology. This step facilitated a more comprehensive understanding of how linguistic elements combine to convey specific meanings within the context of agricultural technology.

To ensure the robustness of the findings, the identified lexical patterns and semantic nuances were subjected to cross-linguistic validation. Bilingual experts proficient in both Uzbek and English independently reviewed and validated the identified patterns, contributing to the reliability of the results and mitigating potential biases in interpretation. In adherence to ethical research practices, this study prioritized the respectful and accurate representation of cultural and linguistic aspects.

**Results.** The analysis of the Uzbek corpus revealed a lexicon deeply rooted in the region's agricultural heritage. Terms often reflected a connection to specific crops, traditional farming practices, and climatic considerations unique to Uzbekistan. Linguistic patterns showcased an integration of Turkic elements, underlining the cultural influence on the expression of agricultural technology concepts in Uzbek. In contrast, the English corpus exhibited a dynamic and globally influenced lexicon. The terms encapsulated a broader spectrum of technological advancements, with an emphasis on precision and adaptability. English demonstrated its versatility by assimilating terms from various sources, reflecting the language's role as a facilitator

of international discourse in the field of agricultural technology.

The cross-linguistic analysis uncovered both convergence and divergence in lexical choices. While certain concepts were universally expressed, semantic variations emerged, highlighting the impact of cultural nuances on terminology. The analysis indicated instances where Uzbek emphasized traditional practices and English leaned towards cutting-edge technologies, showcasing how each language uniquely shapes the narrative of agricultural technology. Semantic analysis unveiled nuanced meanings embedded in the terms. Words with seemingly similar translations often carried distinct connotations, revealing the subtleties in how concepts are perceived in each language. This layer of analysis enriched the understanding of the semantic dimensions, emphasizing the importance of context in interpreting agricultural technology terminology.

The extraction of lexical patterns showcased structural elements within the terminology. Prefixes, suffixes, and roots provided insights into the construction of terms, contributing to a deeper understanding of linguistic processes. These patterns, when examined across languages, highlighted both shared linguistic roots and language-specific adaptations. The study identified instances where cultural influences played a significant role in lexical choices. Traditional practices embedded in the Uzbek lexicon contrasted with the globalized and technology-driven vocabulary in English. This emphasized the intricate relationship between language, culture, and the evolution of terminology in the agricultural technology domain. The results underscore the dynamic interplay of linguistic, cultural, and semantic factors in shaping the lexicons of agricultural technology in Uzbek and English. The nuanced findings contribute to a more profound understanding of how language influences the perception and

communication of agricultural technology concepts in diverse linguistic and cultural contexts.

**Discussion.** The findings of this study illuminate the profound influence of cultural nuances on the lexical choices made in the discourse of agricultural technology. In Uzbek, a language deeply tied to regional agricultural practices, terms exhibited a resonance with traditional farming methods and specific crops. This cultural underpinning contrasts with English, where the lexicon reflects a more globalized and technologically-driven perspective. The discussion of agricultural technology in each language serves as a linguistic mirror reflecting the cultural values embedded in these expressions.

The cross-linguistic analysis revealed instances of both convergence and divergence in lexical choices. While certain concepts demonstrated universal expression, semantic variations hinted at divergent cultural perspectives. The convergence emphasizes shared understandings of agricultural technology concepts, facilitating cross-cultural communication. However, the identified divergences underline the importance of considering language-specific nuances to ensure accurate and culturally sensitive communication.

The semantic analysis brought forth subtle nuances embedded in the terms, showcasing that seemingly equivalent translations may carry distinct connotations. Understanding these nuances is critical for effective communication, as they contribute to the richness and specificity of the terminology. Moreover, the study highlighted the significance of context in interpreting agricultural technology terminology, emphasizing the dynamic nature of language use in different settings.

The study's implications extend beyond linguistic analysis, touching on the practicalities of cross-cultural communication in the agricultural technology domain. Recognizing cultural

nuances and linguistic variations is crucial for fostering effective collaboration. The insights gained from this research can inform the development of communication strategies that bridge linguistic and cultural gaps, facilitating a more comprehensive and accurate exchange of knowledge in the global agricultural technology community.

**Conclusion.** This Lexical-Semantic study of terms related to agricultural technology in Uzbek and English has revealed a complex interplay of linguistic, cultural, and semantic factors. The exploration of lexicons in both languages uncovered cultural nuances deeply embedded in the expressions of agricultural technology. Uzbek, reflecting regional agricultural traditions, contrasted with the globalized and technologically-driven lexicon in English. The cross-linguistic analysis demonstrated both convergence and divergence, emphasizing the need for nuanced cross-cultural communication. Shared understandings of agricultural technology concepts coexist with language-specific expressions, highlighting the dynamic nature of terminology. The semantic nuances uncovered in this study underscored the importance of context in interpreting and conveying precise meanings.

Structural insights gained from the examination of lexical patterns provided a deeper understanding of how terms are constructed. Shared linguistic roots and language-specific adaptations contribute to the richness and diversity of agricultural technology terminology. The implications of this research extend to practical considerations in cross-cultural communication, emphasizing the significance of recognizing linguistic and cultural variations for effective collaboration. In summary, this study contributes valuable insights into the intricate relationship between language, culture, and agricultural technology. The findings provide a foundation for fostering more accurate and culturally sensitive communication, essential for collaboration

in the globalized landscape of agricultural innovation.

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## ECONOMICAL SCIENCES

UDK 338.12

### DIGITAL ECONOMY AND EMPLOYMENT

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**Abstract:**

**Objective.** The global trend of the twentieth century is the penetration of the Internet into all spheres of life. The transformation of economic activity under the influence of the rapid development of online technologies has led to the formation of the digital economy. Innovative technologies of the digital economy help open up new opportunities - optimization of business processes, costs, open up new directions for attracting capital and promoting business projects.

**Results.** Increasing the efficiency of the digital economy based on modern science and technology, increasing consumer demand for products and services, and providing quality goods through the introduction of new equipment and technologies into the production process has become the leading goal in the world. Today, "the share of the digital economy in the gross domestic product of developed countries is 5.5%, and in developing countries - 4.9%. This figure is 12.4% in the UK, 8% in South Korea, 6.9% in China, 5.6% in India, 2.8% in Russia, 3.9% in Kazakhstan" [1].

The "digital economy" has many advantages, the main ones being the prevention of the shadow economy and the eradication of corruption. As a result, BCG estimates that "Internet products generated between \$1.9 trillion and \$14.4 trillion in additional revenue in 2020 and will contribute approximately \$6 trillion to the global economy by 2025" [2].

**Conclusion.** Currently, the world's leading scientific centers and research institutions are conducting a lot of research aimed at solving the problems of transition to a digital economy. Conditions for the implementation and development of the digital economy, the main stages and sequence of the transition to the digital economy, ensuring the sustainability of economic growth in these conditions, characteristics of qualitative factors of economic growth, their impact on the overall balance and sustainability, problems in the methodology for assessing this impact and ways to solve them, among They include general and specific aspects of digitalization in developed and developing economies, optimizing the share of digital technologies in economic growth factors.

**Keywords:** economic growth, digital economy, infrastructure, e-business, e-commerce, information and digital technologies.

**Introduction.** The formation of the digital economy in the CIS countries began from the moment they gained independence and continues today.

Table 1  
**Stages of development of the digital economy in the CIS countries**

Chronological period		Characteristic
First stage	1990-2000	Creation of infrastructure for the formation of an information environment
Second phase	2000-2010	Users have become the source of information creation, the emergence of e-business and e-commerce.
Third stage	2010-2020	Development of social networks, instant messengers and mobile applications.
Fourth stage	2030-2040	Development of social networks, instant messengers and mobile applications.

Research on computer, information and digital technologies is being popularized, which stimulates the strengthening of the position of the digital economy. To systematize its periods of

development, the digital economy should be divided into several chronological stages, which are given in Table. 1

The prospects for the development of the digital economy and its impact on

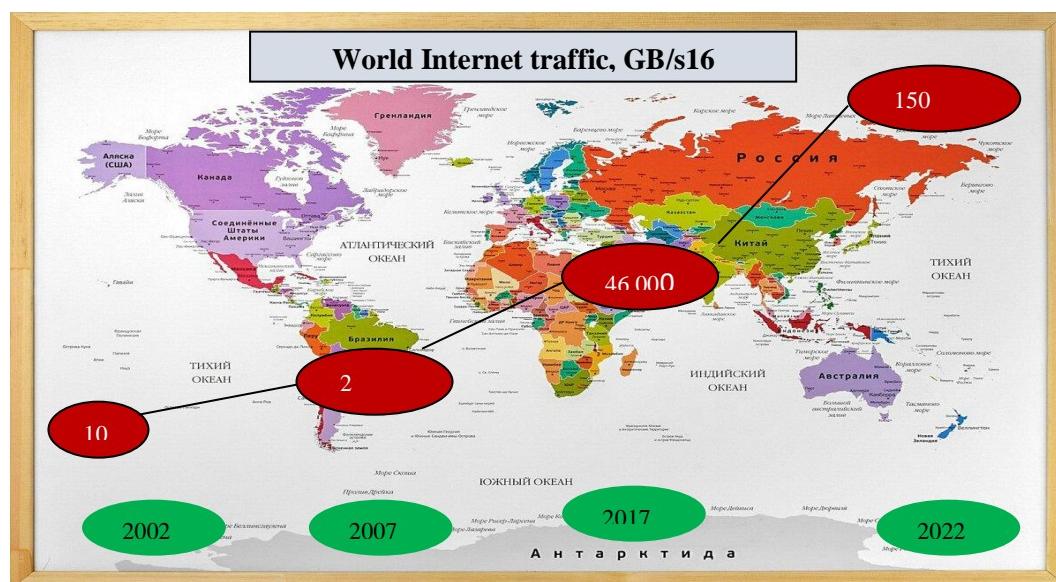
strengthening the state of each national economy cannot be overestimated. Here are a few key facts. According to studies by the Boston Consulting Group and the World Bank, the digital economy in developed countries reaches from 10% to 35% of GDP, from 5% to 20% of GDP in developing countries. The gap between these indicators is explained by the number of accumulated digital assets, the formation of digital services, as well as the implementation and interaction with them of the corporate sector, which generally uses digital technologies [3].

The digital asset size of the ICT (information and communications technology) services sector is about 22%, financing services is 15%, and technology manufacturing is about 14%. It should also be taken into account that the traditional sector of the economy itself was able to acquire a fairly large supply of digital assets, because they can be estimated at about 5% of the gross added value of the

sector. The digital economy is projected to account for about 25% of total global GDP by 2025.

According to domestic experts, the total share of the digital economy in the CIS countries as of 2020 is 4–5%, and over the next five years it could double. Despite such forecasts, this indicator still remains unsatisfactory compared to the share of the digital economy in GDP with more developed countries of the world, which stimulates the adoption of more effective measures.

ICT is among the key innovative components of the modern world. They represent a new technological paradigm belonging to the type of General Purpose Technologies (GPT), which are widely used and adapted to different sectors of the economy. There are two main characteristics of GPT: generality of application and innovative complementarity.



**Fig. 1. Map of global Internet traffic, GB/s16 [4]**

The size of the ICT market in developed countries, according to some estimates, ranges from 3% to 6% of GDP. In 2020, according to McKinsey forecasts, this figure should reach 9% [5].

Table 2  
IT costs in the world [6]

YEARS	2017 y.	2018 y.	2019 y.			
Indicators	Expenses, \$ billion	Growth in %	Expenses, \$ billion	Growth in %	Expenses, \$ billion	Growth in %
Data processing systems	178	4,4	179	0,6	179	-0,2
Enterprise software	355	8,9	389	9,5	421	8,4
security	667	5,7	704	5,6	710	0,9
Devices	933	4,3	985	5,5	1 030	4,6
Communication services	1 393	1,3	1 427	2,4	1 443	1,1
In general IT	3 526	3,8	3 684	4,5	3 783	2,7

Industrial computer services is a unique subsector, growing in all regions and one of the main sources of employment in the ICT sector. Among developing countries, India accounts for the largest share.

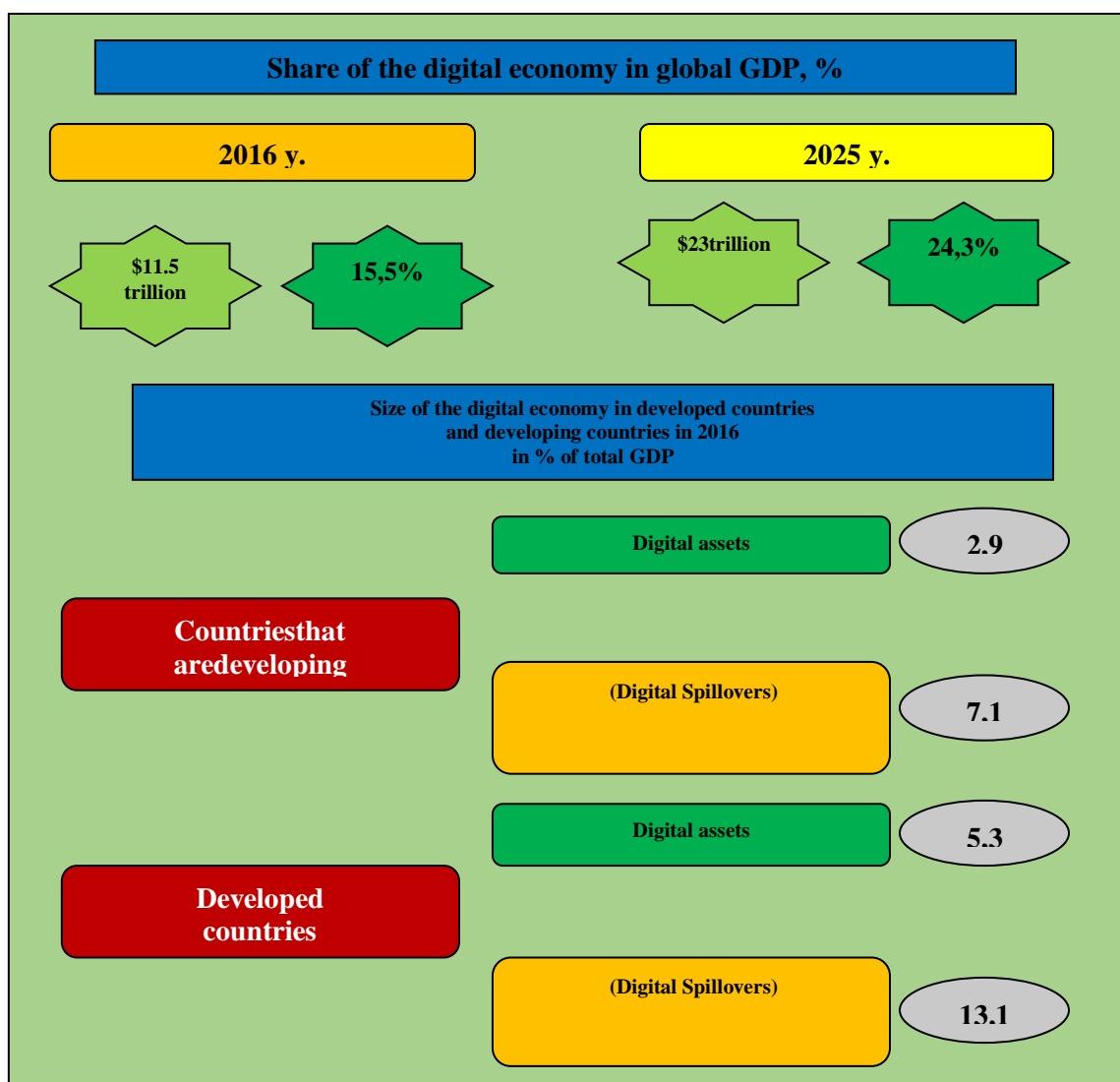


Fig.2. Some indicators of the digital economy [8]

The added value created in the production of products using ICT mainly comes from East Asia (primarily China) [7], and the capabilities of other developing countries are still quite limited. Over the past 10 years, global exports of ICT services and services carried out using digital technologies have been growing much faster than all export services as a whole, indicating the increased digitalization of the global economy.

Depending on the definition used, the size of the digital economy [9] is estimated to be between 4.5% and 15.5% of global GDP [9]. About 40% of the added value created in the global information and communications technology (ICT) sector comes from the United States and China.

**Methods.** The research used methods of systematic analysis, statistical observation, statistical aggregation and grouping, selection, correlation and regression analysis, econometric modeling and forecasting.

**Results.** The number of people employed in the ICT sector worldwide has grown from 34 million in 2010. to 39 million people in 2015, with the largest percentage (38%) of those employed working in the computer services sector. Over the same period, the share of the ICT sector in total employment increased from 1.8 to 2% [10]. According to the World Bank, the introduction of digital technologies leads to the blurring of geographical and physical boundaries and opens up new prospects for the economic, social and cultural development of countries, as well as to increased regional and global competitiveness.

In the digital economy, both the nature of work and the entire system of labor relations are changing. Digital technologies create a specific labor process and make significant changes to its elements: subject, means, technologies, organizations and results of labor. In the modern information economy, it is information that is the subject of labor. A

special feature of the digital labor market is its global nature.

**Discussions.** The digital labor market consists of the interaction of an employer with an employee on a digital platform in a remote work mode. An employee can be employed remotely beyond territorial and national borders if his competitiveness and working conditions allow this.

Segmentation of the global market on the basis of the mandatory use of information and computer technologies at all stages of labor activity allows us to talk about the emergence of a specific segment of the labor market: job search, receiving an order, its execution, transfer of work results and receipt of remuneration.

Work media are digital devices such as computers, tablets, cell phones, cameras, etc. The initial information necessary for carrying out work activities is recorded in digital form. The activity of a specialist is aimed at information, who, thanks to his knowledge, experience and ability to innovate, makes changes to it. So, in summary:

- the digital labor market is a specific segment of the global labor market, in which demand and supply for digital labor services are formed remotely, while the interaction of its subjects occurs exclusively using information - computer technologies;

- digital employment is a useful and expedient activity of the economically active population through the use of information and computer technologies, the result of which is an information product, and the activity itself It is aimed at satisfying public and personal needs and is economically beneficial for both workers and employers.

- supply and demand for labor are recorded on special online platforms, where the conditions for hiring, payment and evaluation of labor results are also formed. The main difference between the digital market is that the interaction of digital labor market players occurs through

various online platforms, which are a meeting place for workers and employers, as well as wage agreements. A product sold in the digital labor market is an employment service created with the help of information and information technology.

➤ the digital labor market is characterized by a high level of flexibility, which is associated with an almost unlimited level of labor mobility. At the same time, the main characteristic of the mobility of this segment of the labor market is its virtuality. That is, the movement of labor occurs without its physical movement from one point in the world to another. Experts highlight the formation of a new type of mobility - digital, which occurs without the physical movement of labor, which significantly reduces the cost of its maintenance for the employer.

➤ globalization and information technology are increasing the level of competition, from one level to another, they will have a competitive personality with a level of professionalism, armed, relaxed, with the balance of reboot and ready to work, and ready to have ready -for today.

In the digital labor market, knowledge work is becoming the most in demand, which is due to the specifics of the services provided. Holders of human capital received a new level of freedom and opportunities for self-realization, and employers gained access to the world's intellectual resources. The digital labor market contributes to the creation of innovative jobs.

The carriers of innovative human capital are individuals who constantly improve their knowledge and professional skills and use them to produce innovations in any field of activity using ICT. The digital space is being actively explored primarily by economically active youth. A report from the US Bureau of Labor Statistics shows that digital workforce demographics are dominated by employees between the ages of 16 and 35, who make up 50% of all employees in this segment.

➤ The main customers of labor services in the virtual labor market are innovative global companies and young fast-growing companies. The digital labor market is characterized by a high level of dynamism. There are four models of labor market dynamics depending on the ratio of factors: the intensity of labor force restoration (high, low) and the intensity of job restoration (high, low): a model with a high labor turnover, when the labor market demonstrates the ability to quickly update the structure of jobs .

➤ The model also corresponds to their part, where innovative human capital is concentrated, engaged in the production of innovations, research and scientific development. Labor services in this market segment are characterized by a high level of intelligence, and the result depends on the individual's ability to innovate, work with dynamic information flows, and make non-standard decisions. enia.

➤ To more effectively use human potential, employers are forced to invest in the acquisition and development of new technologies. The "arrow" model assumes that the labor market is capable of moving directly, without deviations, to a new employment structure, which is formed by shifts in demand, changing technological and institutional conditions. This model covers those employed with remote service.

At least 30% of functions within professions can be automated at the current level of technology development [11]. At \$9 trillion. in 2030 can grow global GDP thanks to automation of jobs using AI technologies[12]. 375 million workers (about 14% of the global workforce) will be forced to change occupations by 2030. 98% – probability of automation of such professions as bank teller, auditor, credit specialist [13]. The number of working hours in professions that by 2027 may decrease by 29%. will not disappear thanks to the introduction of AI in the banking sector of China [14].

**Conclusion.** Thus, the modern global labor market is a complex, multicomponent and dynamic system, which is subject to the permanent influence of information technologies, which, in turn, entails changes in the content of the labor process, its organization, employment structure, social-labor relations, and also requires training employees in fundamentally new skills. Digital technologies have created a completely specific labor process and have made changes to all its elements: the subject of labor, means of labor, technology, organization and the result of labor.

At the same time, one can hardly agree that the impact of new technologies on labor resources is predictable. This

process is complex because it is not so much about innovative technologies, but about how people are going to use them. So, thinking about the future of the labor market and employment, questions arise that need to be answered: how will technology changes, automation and artificial intelligence affect work activity, where and how will we Let us work, what will be the place of the worker in this "working" world.

Digitalization has a significant impact on employment and the labor market, in particular, it is a prerequisite for new opportunities for creating new jobs. Although it must be added that data on the impact of digitalization on the creation of new jobs is still very contradictory.

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## ECONOMETRIC ANALYSIS OF THE ACTIVITIES OF MULTI-SECTORAL FARMS

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### Abstract:

**Objective.** Studies show that the demand for food products is expected to increase by 60 percent by 2050. This poses a serious challenge to agriculture and food systems around the world in the face of climate change, limited natural resources and the emergence of new types of demand. In developing countries, it is observed that small producers play a leading role as producers of most of the food to meet the needs.

**Results.** Indeed, in Asian countries, small producers play a crucial role in meeting the demand for food. This is especially true during the Green Economy, when small farmers began to adopt new techniques, increase productivity, and produce enough food to lower and stabilize real consumer prices of staple foods. In rural areas, the demand for labor has increased, jobs have been created for the poor rural population, and their wages are increasing. A combination of these factors helped ensure food security for all.

The progress made in the last 20-40 years is based on the work of small producers [1]. During the same period, small farmers tended to be more efficient than large farms. In the future, small producers may be more efficient in producing labor-intensive products.

**Conclusion.** The world food system will face unprecedented pressure from a variety of factors over the next 40 years. In terms of consumption, the world population is expected to increase from approximately seven billion today to eight billion by 2030 and nine billion by 2050.

**Keywords:** agriculture and food systems, lower and stabilize real consumer, , small producers, agricultural products, animal husbandry.

**Introduction.** In the meantime, many people are expected to live more prosperous lives, creating a demand for high-quality varieties that require additional resources to produce (Table 1)[2].

**Table 1**

**The main indicators of the agricultural economy**

Indicators	2000	2005	2010	2015	2016	2017	2018
Agricultural products, bln. soum	1387.2	5978.3	30856.7	99604.6	115599.2	148199,3	192699.2
Agricultural crops cultivated area, thousand hectares	3778.3	3647.5	3708.4	3694.2	3706.7	3474,5	3396.0
Agriculture, bln. soum	696.8	3323.1	18119.0	55429.2	61755.1	83303,4	102495.1
Animal husbandry, billion soum	690.4	2655.2	12737.7	44175.4	53844.1	64895.9	90204.1

From the data of Table 1, it can be seen that in 2000, 1387.2 bln. 50.2 percent of the output is 696.8 billion soums. agriculture and 49.8 percent of 690.4 billion soums. 3778.3 thousand soums of livestock products were produced in the state where agricultural crops were cultivated.

By 2018, agricultural output will increase by 38.9 times compared to 2000 to 192,699.2 billion. amounted to soum. Agriculture is 53.2 percent 83303.4 billion. soums and livestock products 46.8 percent 64895.9 billion. amounted to soum. At this time, the cultivated area of agricultural crops decreased by 382.3 hectares in 2018 compared to 2000, and the achievement of such a positive result indicates that effective production was established mainly through intensive development, that is, on the basis of land reclamation and efficient use of water.

**Methods.** The article uses methods such as statistical analysis, monographic observation, induction and deduction, abstract reasoning, economic and mathematical modeling, expert and rating assessment.

**Results.** The main reason for the low profitability and profitable activity of agricultural enterprises is the development of production at the expense of own accounts and appropriated funds, the reduction of investments, the low wages of employees of agricultural enterprises, and

the differences in the prices of products sold in agricultural products and industrial products. In many agricultural enterprises, production profitability is related to low wages of employees. This factor is almost crucial to maintain profitability for most of the farms in the region. If the farm is multi-sectoral, then it should be distinguished by the fact that the accounts of these farms have much more funds compared to a regular farm and the possibility of using these funds for the intended purpose.

**Discussions.** This, in turn, plays an important role in motivating employees and increasing their enthusiasm for work, as well as ensuring product competitiveness. In order to improve the social conditions of the rural population, to increase their well-being, to increase human potential, to motivate them to work, employees in the agricultural sector require an increase in wages.

Of course, the increase in wages and the associated additional tax burden will reduce the profitability of the industry. This is especially noticeable in areas with less favorable conditions for agriculture. According to the results of the research, it was observed that after the establishment of multi-sectoral farms, the possibility of overcoming social problems between increasing wages and possible negative consequences in agriculture (decrease in the profitability of agricultural production

and weakening of its position in the competitive struggle) increased.

Based on the organization of multi-sector farms, it will be possible to organize agricultural products processing, cooperation with neighboring agricultural enterprises and other additional complex structures managed by agricultural producers.

In order to further increase the activities of multi-sector farms, marketing services can be formed to sell the produced products in urban or business structures. The use of this principle in public-private sector cooperation provides the following opportunities:

increase the profitability (income) of multi-branch farms;

strengthening the relations of multi-branch farms, households and peasant (farmer) households and increasing the volume of product sales;

increase the real income and employment of the rural population.

It is possible to solve the problem that arises in the development of rural areas (increasing the income of the population, ensuring employment, etc.) through the sufficiently effective organization of multi-branch farms, and in this regard, first of all, it is necessary to train highly qualified personnel and improve the qualifications of farm managers.

Based on the results of the analysis, it is necessary to implement a number of

priority tasks in order to increase the efficiency of multi-branch farms. Including:

balancing the use of agricultural land; increasing the productivity of agricultural products;

maximum use of export opportunities for agricultural development;

increase the efficiency of the use of budget funds for financing agriculture;

protection of land ownership rights of farms;

improvement of effective management mechanisms of multi-branch farms, development and implementation of modern management methods.

Along with the growth of the gross domestic product, development of its network structure is one of the urgent issues of today's era. In this sense, it is appropriate to study the influence of factors on the change in the volume of the gross product of farms of the Republic of Uzbekistan based on the scope of the research work, for this purpose, the volume of investment in agriculture as factors influencing farm product - Y - X1, population density in the area (per year, population per 1 sq. km). Real total income per capita - X2, the number of people employed in the network - X3 and the population density in the country (per year, the number of people per 1 sq. km) - X4 were selected and the econometric regression equation was determined and analyzed (Table 2).

**Table 2**  
**Correlation coefficient between the selected factors of the gross output of farms of the Republic of Uzbekistan**

	Y	X1	X2	X3	X4
Y	1	-	-	-	-
X1	0,752336	1	-	-	-
X2	0,98506	0,787484	1	-	-
X3	0,897593	0,515908	0,79501	1	-
X4	0,957394	0,81823	0,954609	0,979945	1

According to the data of Table 2, it was found that all the factors are strongly connected with the resulting factor agricultural output, however, the country's population density (population per 1 sq. km per year) – X4 factor with other factors ( $r_{(x1,x4)} = 0.81823, r_{(x2,x4)} = 0.9546$  and  $r_{(x3,x4)} = 0.9799$ )  $r_{(\sim n, x_{(n+1)})} > 0.8$  because it creates multicollinearity , in

order to ensure the reliability and adequacy of the model, we exclude the factor of population density in the country in the study. Now, based on the selected indicators, we move from the variation of the measurement units to the logarithm and continue the process by defining the regression equation and using the Ewievs program to check its reliability and adequacy (Table 3).

Table 3

**Criteria-based testing of regression equation coefficients and reliability**

Dependent Variable: LNY				
Method: Least Squares				
Date: 12/03/20	Time: 12:32			
Sample: 2000 2019				
Included observations: 20				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNX1	0.442429	0.402704	1.098645655	0.0120
LNX2	2.192569	0.940448	2.331409073	0.0329
LNX3	0.039426	0.682030	0.057806841	0.0462
C	-13.44545	10.01737	-1.342123177	0.0094
			$t_{jad}=2,119905285$	
R-squared	0.959137	Mean dependent var		8.512908
Adjusted R-squared	0.951476	S.D. dependent var		2.030439
S.E. of regression	0.447270	Akaike info criterion		1.405550
Sum squared resid	3.200814	Schwarz criterion		1.604696
Log likelihood	-10.05550	Hannan-Quinn criter.		1.444425
F-statistic	125.1851	Durbin-Watson stat		1.845037
Prob(F-statistic)	0.000000	$F_{jad}=3,238871522$		

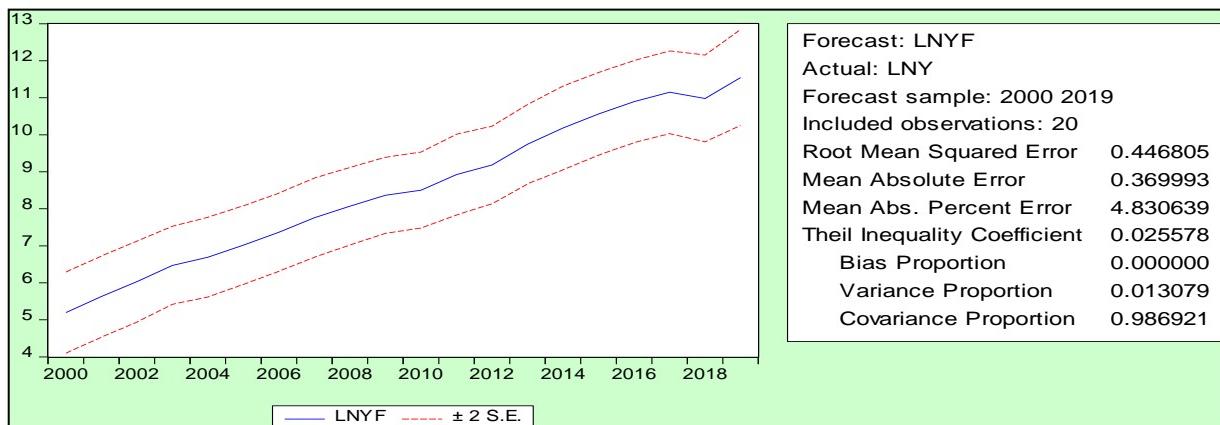
Based on the data of Table 3, it should be noted that the determined regression equation (1) is expressed as follows:

$$\ln Y = 0.44 \ln X_1 + 2.19 \ln X_2 + 0.04 \ln X_3 - 13.454445 \quad (1)$$

We can exponentiate this logarithmic equation (1) to bring it to a linear equation, and according to it, the logarithmic equation (1) will look like this:

$$Y = \frac{x_1^{0.44} * x_2^{2.19} * x_3^{0.04}}{e^{13.454445}} \quad (2)$$

We check the significance of the determined equation (2)  $\alpha=0.05$  for the case  $F_{jad}=3,239$  when  $k_1=3, k_2=16$ . According to the data in the table, the regression equation (2) determined by the fact that  $F_{this}=125.2$  and  $F_{this}>F_{condition}$  is fulfilled is significant, but ( $t_{jad}=2.12>t_{x1}=1.0986$ ;  $t_{x3}=0.058$ ) according to  $t_{jad}>t_{this}$  condition MAPE this parameter We check with the criteria  $<10$  and TIC $<1$  (Fig. 1).



**Figure 1. Assessing the retrospective predictive quality of a variable**

According to the condition, - due to the good accuracy of the forecast and using  $MAPE=4.83<10$  and  $TIC=0.026<1$ , parameters  $X_1$  and  $X_3$  were also proved to be significant, and model (2) determined from  $DW=1.85\leq 2$  was reliable and adequacy arises.

According to regression equation (2), 1 bln. increase to 0.6 billion sums of the gross output of farms. to soums, increasing the total real income per capita by 5.6 million soums. 15.8 mln. per soum and by increasing the number of items in the

network by one unit. it was found that it is possible to increase it to soum.

Now, in Namangan region, which is the object of the research, the factors affecting the gross output of farms-Y are the number of people employed on the farm -  $X_1$ , the area of agricultural crops -  $X_2$ , real total income per capita -  $X_3$  and the population density in the area (per year, 1 sq. .population per km)- we will continue the research on  $X_4$ . According to its results, the following were determined (Table 3).

**Table 3**  
**Correlation coefficient between factors of the agricultural product of Namangan region**

	Y	X1	X2	X3	X4
Y	1	-	-	-	-
X1	0,884914	1	-	-	-
X2	0,794147	0,524794	1	-	-
X3	0,894589	0,798956	0,525572	-	-
X4	0,98861	0,927926	0,881338	0,936035	1

Based on the information in the table, all the factors selected for the volume of agricultural products are strongly connected and the population density in the area (per year, population per 1 sq.km) with other factors ( $r_{(x_1,x_4)}=0.9279, r_{(x_2, x_4)}=0.8813$  and  $r_{(x_3,x_4)}=0.9360$ ) created multicollinearity under the condition  $r_{(x_{\sim},x_{(n+1)})}>0.8$ . According to it, we continue to determine the regression

equation with the remaining factors, population density (population per 1 sq. km per year)-  $X_4$ . It should be noted that since the measurement units of the selected factors are different, we logarithmize all indicators, and this, in turn, determines the regression equation will not have a linear form. For the regression equation, it is first required to check the coefficients and their reliability and significance, which is done using the Ewievs program (Table 4).

Table 4

**Regression equation coefficients and test results for reliability criteria**

Dependent Variable: LNY

Method: Least Squares

Date: 12/02/20 Time: 15:15

Sample: 2000 2019

Included observations: 20

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNX1	1.089575	3.61693	0.301243	0.0537
LNX2	0.798733	9.14803	0.087312	0.0319
LNX3	1.241637	0.40453	3.069332	0.0075
C	-13.0831	55.7804	-0.23455	0.0452
			$t_{jad}=2.119905$	
R-squared	0.989727	Mean dependent var		11.32019
Adjusted R-squared	0.987801	S.D. dependent var		1.545551
S.E. of regression	0.170705	Akaike info criterion		-1.520907
Sum squared resid	0.466241	Schwarz criterion		-1.321761
Log likelihood	9.209074	Hannan-Quinn criter.		-1.482032
F-statistic	513.8349	Durbin-Watson stat		1.9292811
Prob(F-statistic)	0.000000	$F_{jad}=3.006917$		

According to the table, the defined regression equation (3) looks like this:

$$LnY=1,089575LnX1+0,798733LnX2+1,241637LnX3-13,0831 \quad (3)$$

We can exponentiate this defined logarithmic equation according to the accuracy of calculations and the rule of use. Then the regression equation (3) is:

$$Y = \frac{X1^{1,0896} * X2^{0,798} * X3^{1,242}}{e^{13,083086}} \quad (4)$$

will have an appearance. Now we check the significance of the coefficients of equation (4) according to the Student's test. It is known that  $t_{jad}=2.119905$  when  $\alpha=0.05$  and  $df=16$ , and only  $t_{x3}=3.069$  parameter is significant in this model.

According to the condition,  $MAPE<10$ , and according to the conditions  $MAPE=1.236<10$  and  $TIC=0.0067<1$ , all the investigated parameters were proved to be significant. Now we test the significance of this regression equation according to Fisher's test. When the result is  $k1=3$ ,  $k2=16$ ,  $F_{jad}=3.006917$ , according to the table, it is equal to  $F_{this}=513.8$  and since the condition  $F_{this}>F_{jad}$  is fulfilled, the regression equation (4) is significant and the model determined from  $DW=1.929\leq 2$  is reliable and adequate. comes out.

**Conclusion.** According to the regression equation (4), at present, by

increasing the employment of the population in the farms of Namangan region by one unit, the land area by one hectare, and the real total income per capita by one thousand soums, the volume of farm products will be 15.9 million, respectively. 39.1 million soums. soums and 0.15 mln. the possibility of an additional increase to soum was determined.

In conclusion, the consistent implementation of these tasks will serve to develop production capabilities and increase the synergistic efficiency of farmers and multi-sectoral farms, as well as the integration of agricultural cooperatives in the framework of joining the World Trade Organization and encouraging cooperation and cooperation with agribusinesses and exporters.

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## PROSPECTS FOR THE DEVELOPMENT OF SMALL AND MEDIUM BUSINESS IN NAMANGAN REGION

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### Abstract:

**Objective.** The purpose of the study is to analyze the five-year development of small and medium-sized businesses in Namangan region, and determine the future development prospects of the region.

**Methods.** Methods such as synthesis, scientific knowledge, statistical analysis, factor analysis, comparison, comparison were used in the research process.

**Results.** Based on the analysis carried out in the research, the growth points of the development of small and medium business in Namangan region are identified and the future directions of development are determined.

**Conclusion.** We believe that the recommended information, analysis, and conclusion will serve the development of small and medium-sized businesses in the Namangan region in the future.

**Keywords:** entrepreneurship, small and medium business, export, brand, subsidy, foreign demand.

**Introduction .** Favorable conditions for the development of small and medium-sized businesses in our country, as well as long-standing traditions of high productivity and entrepreneurship of the population, have created a solid foundation for rapid development of entrepreneurship in Namangan.

Doing business in the region is increasing. Therefore, as of January 1, 2023 , the number of small business entities is 32,305. It is a natural situation for the region. In 2022, 72.8 percent of the gross regional product of Namangan region was produced by small businesses and entrepreneurial entities.

the last five years, the number of enterprises in Namangan region has increased by 15 thousand and exceeded 32 thousand. During this period, the volume of products produced by private business increased by 1.6 times and reached 8.3 trillion soums. Namangan has taken the highest place among the regions

of our country in terms of private business growth .

During his visit to the region on February 3, 2022, the President expressed the following thoughts in this regard: "Imagine that the region, which was subsidized six years ago , today has a solid income, modern industry and strong entrepreneurs have formed. To put it simply, Namangan has become, without exaggeration , the land of entrepreneurs, the center of small and medium business.

**Methods.** In general, the organization of small industrial zones in our country has become very important in the development of entrepreneurship . In particular, 778 projects are located in these complexes in Namangan region, and about 26 thousand jobs were created in them in 2017-2022 .

In this field, the share of Namangan region in the republic is very high, that is, the share of the region in the projects launched in the small industrial zones of our country is 21.2%. The total value of

these complexes in the region is 3103.345 billion. 364 projects worth soums have been implemented. In 2022, the volume of production in small industrial zones will be

3141.655 billion. amounting to soums , of which 36.6 mln. dollar product is exported (Table 1).

Table 1

**Dynamics of foreign economic activity of Namangan region in 2017-2022**

(million USD)

Name	2017	2018	2019	2020	2021	2022	Total
<b>Regional foreign trade turnover</b>	<b>573,7</b>	<b>1202,6</b>	<b>987,6</b>	<b>873,8</b>	<b>1091</b>	<b>1276,1</b>	<b>6004,8</b>
<b>Export</b>	<b>196,7</b>	<b>247,4</b>	<b>357,3</b>	<b>380,5</b>	<b>496,2</b>	<b>581,2</b>	<b>2259,3</b>
<b>Import</b>	<b>377</b>	<b>955,1</b>	<b>630,3</b>	<b>493,4</b>	<b>594,8</b>	<b>694,9</b>	<b>3745,5</b>

Namangan is one of the largest and modern textile centers of our country. As a result of the favorable business environment created in our country for foreign investors, ready-made clothes with the brands of such companies as "Waikiki", "Baldessarini", "ZARA", "HUGO BOSS", "FUN DAY" are made in the region and they are exported to foreign countries. Textiles have become the driver of the regional industry.

an example , let's take a look at the activity of the "Fazman textile" enterprise, which started working in 2022. The total value of the enterprise is 20 million dollars. He has established cooperation with the world famous German brands "Digel" and "Carl Gross" . The enterprise is equipped with modern equipment, the most advanced technologies in the field of textiles are imported from Germany and Turkey. About a thousand jobs were created there . The company has the capacity to produce 1 million men's suits and trousers per year. They are stylish and of high quality due to their compliance with global requirements. It is planned to export 15 million dollars this year .

The management of "Fazman textile" has also established a special training center for the purpose of training high-level and knowledgeable personnel .

Business entities are not limited to working only under the brands of foreign companies. Many of them have already created their own brands and they are well known in foreign countries and are highly competitive in terms of quality and price in the world market. In particular, local brands such as AishaHomeTextile, Ideal, Vakkoni Collection, D.MARETTI under the name " Made in Uzbekistan " are conquering the world clothing markets today.

fully processes all cotton raw materials grown in the region by business entities . The pace of their development is so high that recently 4 thousand tons of cotton fibers are being imported from Kashkadarya and Surkhandarya, and 0.8 thousand tons from the Islamic Republic of Iran.

, special attention is paid to the tradition of "Master-disciple", which has been popular among our people since ancient times, in training young people in entrepreneurship and profession . In this regard, Namangan region is becoming an example for the regions of our country .

**Results.** This process is systematically launched in the region . As a result, in 557 neighborhoods of the region, young people are engaged in learning dozens of crafts, such as knife making, blacksmithing, tailoring, carpentry, and beekeeping. In particular, in 2022, about

230 training courses were organized in the region based on the tradition of "master-apprentice", as a result, more than 2,500 young people were trained in trades in one year.

Also, under the guidance of more than 900 master craftsmen, 6,303 apprentices were trained and jobs were created for them. The state pays great attention to the development of the industry. 6.9 billion soum for 132 projects within the framework of the craft development program alone. Soum preferential loan was allocated.

For example, in 2020, the enterprise "Sifat Yog Okh Syudy" was established. At the moment, this enterprise is developing and the annual turnover is 10 billion soum. There is great interest in these products abroad. In 2022 alone, the craftsman exported \$700,000 worth of handicrafts. In 2023, the volume of exports to neighboring countries will be 1 mln. soum. earnestly determined to increase from the dollar. At one point, he taught his profession to young people.

The geography of export of craft products from Namangan region has been expanding, and Chust knives, ceramics, embroidery products, and metal products produced by regional artisans have been exported to the USA, Latvia, Lithuania, Georgia, the Russian Federation, and the Kingdom of Belgium. A total of 1,740 mln. soum will be allocated for the organization of exhibitions of national handicraft products in the building of diplomatic and embassies of our country in foreign countries. Soum worth of product was delivered.

Online sales of them have been launched. The website "Craftshipman.com" has been created and offers customers embroidery, adres, satin, carving, metalwork, miniatures, paintings, small sculptures. About 380 crafts have been posted on the site, and more than \$3,500 has been generated through online sales. artisans are also making good use of social media to promote online sales, with

\$629,384 worth of handicrafts sold through online stores.

small businesses is very high in agriculture, forestry and fisheries (94.6%) and retail trade (92.3%). The fish caught in the region last year amounted to 14,153.2 tons. "DB Group Eco" enterprise operating in Uchkurgan district produced 553 tons of fish products last year. The enterprise intensively cultivates valuable and rare fish species such as salmon and trout and sells them to the domestic and foreign markets. "DB Group Eco" enterprise provided employment to 50 young people in the neighborhood.

Namangan businessmen have huge plans for the "year of attention to people and quality education". In particular, it is planned to implement 250 new projects in the textile and sewing-knitting industry in 2023-2026. The total cost of the projects is 10.9 trillion soum. 51,200 new jobs will be created.

6.5 billion soum of regional commercial banks in the field of crafts in 2023. 1,985 projects are planned to be implemented at the expense of soum loans. It is envisaged to organize educational seminars and trainings in order to improve the knowledge and skills of craftsmen in the field of online trade and tourism. This, in turn, serves to increase the number of craftsmen working in the electronic commerce system from 220 to 500, and the number of craftsmen working in the field of tourism from 1520 to 2500.

The geography of export of craft products from Namangan region has been expanding, and Chust knives, ceramics, embroidery products, and metal products produced by regional artisans have been exported to the USA, Latvia, Lithuania, Georgia, the Russian Federation, and the Kingdom of Belgium.

**Discussions.** President Shavkat Mirziyoev, during his visit to Namangan region on February 3, gave the same assessment to regional entrepreneurs. In fact, the people of Namangan have been famous in Central Asia for their

entrepreneurship and business acumen. Namangan region on February 3, 2023, President Shavkat Mirziyoyev also talked about new measures to support entrepreneurs. In particular, this year, due to the winter cold, the production of 3 thousand regional industrial enterprises in our country decreased. The tax debt of many entrepreneurs has also increased. Therefore, our President signed a special decision to compensate for losses in the economy and support business. According to him , businessmen who have difficulty in the cold will be given relief in terms of loans, taxes, customs and other payments.

Loan payments of 4.7 trillion soums due in January-March of 2,000 small and medium entrepreneurs will be extended until June 1. 29,000 entrepreneurs will be given the opportunity to pay their tax debt of 2 trillion soums in installments by July 1 without interest, additional collateral and penalties. A loan of 8 trillion soums will be allocated to 545 industrial enterprises with reduced capacity to restore production and working capital . Payments for the purchase and lease of state property will also be reduced . A 10 percent property tax discount will be introduced for entrepreneurs for each upper floor of

industrial buildings. Additional opportunities for the development of entrepreneurship .

**Conclusion.** As a result, in 2023, new high-income jobs for about 500,000 residents will be created in Namangan region. For this, 950 billion soums or 2 times more preferential loans will be allocated for family business in the region this year. A special textile zone will be established and 75 billion soums will be allocated for the infrastructure of 15 industrial zones.

Centers will start operating in each district . 9.5 thousand hectares will be distributed to the population for farming, and marketable food products will be grown on them. Special attention is paid to social support of women and youth.

A land of entrepreneurs , small and medium business center of our country due to the favorable conditions and high entrepreneurial and productive potential of the people of the region . We believe that the number of such areas in our country will continue to increase. After all, all opportunities have been created in this auspicious place for entrepreneurs to participate more actively in the process of establishing New Uzbekistan.

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## ORGANIZATIONAL STRUCTURE OF THE INTERNAL CONTROL SERVICE FOR THE FULFILLMENT OF TAX OBLIGATIONS OF ENTERPRISES

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**Annotation.** The article discusses the issues of the organizational structure of internal control over the fulfillment of tax obligations by business entities, internal and external factors taken into account in the process of creating its organizational structure, the functions and tasks of the internal corporate control service over the fulfillment of tax obligations of enterprises, and substantiates the feasibility of using tax management tools in the methodological support of this special type of accounting and analysis, tools have been developed to ensure the completeness, objectivity and reality of the results obtained, one of the effective methods of corporate tax management - internal control.

**Keywords:** taxpayer, tax obligations, control over the fulfillment of tax obligations by business entities, corporate control, tax management, corporate tax management, corporate standard for monitoring the fulfillment of tax obligations.

**Introduction.** It is well known that in the "Concept of integrated socio-economic development of the Republic of Uzbekistan until 2030", approved with the Decree of the President of the Republic of Uzbekistan No. DP-5614 of 01/08/2019, special attention is paid to the issues of ensuring the financial stability of enterprises using tax management tools [1].

Taxes, as built-in regulators of the state's fiscal policy, are tools of motivation and external restrictions on the financial results of business entities and the profitability of their capital. Optimization of the tax system, ensuring the coordination of the economic interests of participants in

tax relations, determines decisions that determine the positive vector of fulfillment by business entities of their tax obligations.

Institutional imbalance and insufficient constructiveness of mechanisms of inter-subject interaction in the field of tax policy determine the need to improve models of intra-corporate tax regulation and the formation of effective tools in the field of monitoring the fulfillment of tax obligations by business entities. Accordingly, a detailed consideration of the tax segment of corporate control is necessary. Such an analysis will also serve to continue research in this scientific area and will contribute to the effective implementation of an effective model of the

system of tax relations between business entities and the state.

The national economic significance and scientific relevance of the topic of this scientific article are determined by the experience of recent years, which has proven the futility of the practice of episodic attention to the control of their own tax obligations on the part of business entities and has revealed the objective need to improve the existing tools of the control mechanism.

There is an urgent need to modernize existing methods and develop new control and analytical tools (technologies), separating them into a separate independent area of financial science and the practice of corporate control of business entities, systematizing the accumulated scattered theoretical knowledge and fragmentary analysis of practical experience in order to minimize the tax risks of business entities.

The above problem is typical, as a rule, for large and medium-sized businesses, because in small businesses, the costs of creating a full-fledged control system may exceed the benefits of its implementation. Separately, we note that

the study of the problems of state (external) control of tax obligations at the macro level is also extremely relevant, but is the subject of a separate scientific study.

Thus, the unresolved nature of a number of key problems of the organization, the need for the functioning and development of a control mechanism in the sphere of interaction between the state and taxpayers determine the development of new theoretical and methodological foundations for the development of these relations. The importance of the problem under consideration, its practical significance, the need to form a new model and tools for corporate control over the fulfillment of tax obligations by business entities give the topic of this scientific article increased relevance.

**Main part.** The system of corporate tax control of a business entity is based on the following principles (Table 1). Their implementation allows us to ensure continuity, independence, consistency and precautionary nature of corporate tax control of business entities.

Table 1

### **Principles of the system of corporate tax control of business entities<sup>1</sup>**

PRINCIPLE	CONTENT OF THE PRINCIPLE
<b>Independence</b>	An employee or corporate tax control department is directly subordinate to the management of a business entity and should not be associated with or dependent on accounting or any other financial service
<b>Plans</b>	The business entity must develop regulations, compliance with which is verified during planned control activities
<b>Regularity</b>	Control must be carried out systematically and on a regular basis.
<b>Objectivity and reliability</b>	Elimination of subjective assessments and distortion of actual data
<b>Responsibility</b>	Based on the results of control measures, penalties should be imposed on the guilty persons
<b>Legality</b>	The need to comply with tax, civil and other legislation of the Republic of Uzbekistan.

<sup>1</sup>Compiled by the author based on research results

<b>Maintaining tax secrecy</b>	Tax accounting data is a tax secret
<b>Universality of tax control</b>	Control measures should cover all business processes that have tax consequences
<b>Unity</b>	The integrity and unification of corporate tax control is served by the corresponding standard
<b>Timeliness</b>	Control measures are carried out not only before preparing tax reports, but also during the tax (reporting) period
<b>Documentation of results</b>	Control activities are documented with relevant documents (for example, inspection reports)

The procedure for organizing corporate control, including the responsibilities and powers of the divisions and personnel of an economic entity, are determined by its head, depending on the nature and scale of its activities and the characteristics of its management system.

When organizing corporate tax control, it is necessary to proceed from the fact that:

a) corporate tax control should be carried out at all levels of management of a business entity;

b) personnel of the financial services of an economic entity must participate in the implementation of corporate tax control in accordance with their powers and functions;

c) the usefulness of corporate tax control should be comparable to the costs of its organization and implementation.

There are four options for organizing corporate tax control:

- creating your own corporate tax control service (if the business entity has the necessary resources for this);

- outsourcing - the performance of the corporate tax control function is completely transferred to a specialized company

(external tax consultant or auditor/audit organization);

- cosourcing – the creation of a separate corporate control service, in some cases involving experts from a specialized company or an external consultant/auditor.

- outstaffing is the rental of the necessary personnel from a third party.

To organize and implement corporate tax control, a business entity can create a special unit that:

a) provides methodological support for the organization and implementation of corporate tax control;

b) coordinates the activities of departments for organizing and implementing corporate tax control;

c) carries out assessment of corporate tax control.

Creating a special corporate tax control unit is advisable in cases where:

a) the volume of activities related to organizing and assessing corporate tax control is so large that it is economically feasible to entrust the performance of this function to a division that carries out this activity on an ongoing basis;

b) due to the specific nature of the activities of an economic entity, ensuring

the effectiveness of corporate tax control requires the accumulation, preservation and transfer of special knowledge, skills and experience;

c) the risks of a business entity's activities are so high that ensuring the effectiveness of corporate tax control requires the operation of a special corporate tax control unit on an ongoing basis;

d) there are legislative or regulatory requirements for a business entity to create a special unit for corporate tax control (for example, if a company enters into an agreement with the Tax Committee under the Cabinet of Ministries of the Republic of Uzbekistan on tax monitoring).

Such features of control and information support for tax liability management determine the need to create a separate service that performs the function of continuous monitoring and creates a feedback mechanism between the functions of the tax liability management system.

When organizing and implementing corporate tax control over the facts of economic life, a business entity must be guided by the requirement of rationality, which means that if any elements of corporate tax control cannot be applied by a small business entity, since the manager can organize it in any other way that ensures achievement the goals of his activities. For example, the head of a small business entity can assume all the functions of organizing and implementing corporate tax control; if the number of personnel of a business entity does not allow for the division of powers and rotation of responsibilities, a small business entity can use other corporate tax control procedures that help prevent existing tax risks.

It is important to study the distribution of powers and functions for the organization and implementation of

corporate tax control of a business entity (Fig. 1).

Engaging an independent consultant (auditor) to organize and assess corporate tax control is advisable in the following cases:

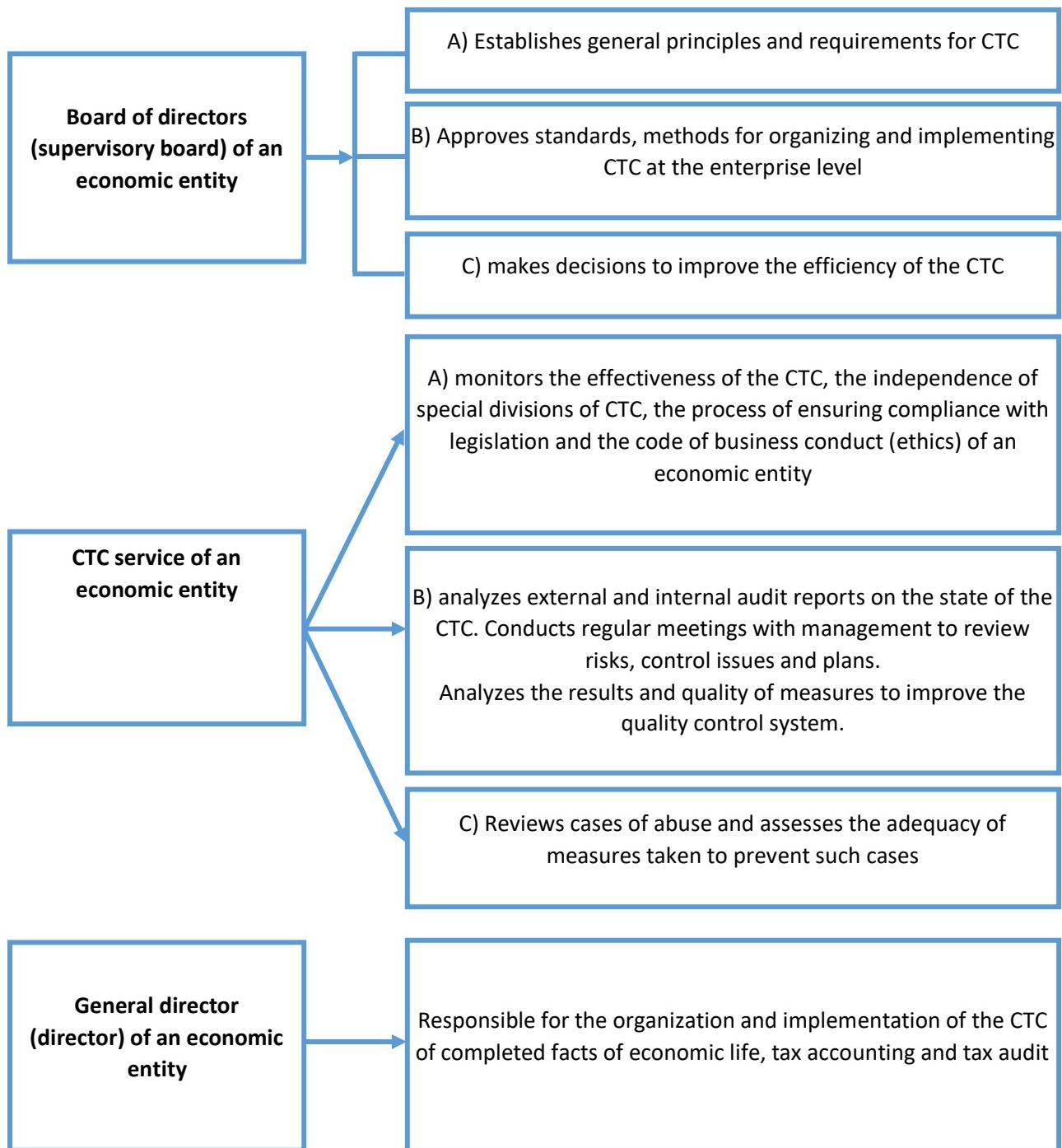
a) if the economic entity's own resources are not enough to complete the tasks of organizing and (or) assessing corporate tax control within the time limits established by regulatory documents;

b) if the planned costs for the creation and subsequent maintenance of a unit providing corporate tax control exceed the cost of attracting a third-party independent consultant (auditor) to perform the tasks of organizing and (or) assessing corporate tax control;

c) if the management of an economic entity is interested in the independence of the assessment of corporate tax control;

d) if the priority for the management of a business entity is to use standard, repeatedly tested approaches to organizing and (or) assessing corporate tax control.

The results of corporate tax control serve as a prerequisite for carrying out other activities based on its results: employee training, external consulting support, etc. Providing methodological and consulting assistance to employees of the accounting service and (or) tax department on issues of setting up and maintaining tax records, ensuring a unified approach to reflecting business transactions in tax registers are control tools, since an employee of the corporate tax control service analyzes the situation and provides a ready-made solution controversial issue. Consulting support for employees requires certain regulation - incoming requests must be recorded and analyzed in order to make further decisions on conducting training events.



**Fig-1. Distribution of powers and functions for organizing and implementing corporate tax control (CTC)\*<sup>2</sup>**

Thus, one of the post-control actions of the administration, which can also be carried out by the corporate tax control service, is training of employees of the accounting service and (or) tax department. The purpose of conducting training events is to timely familiarize

employees with changes in legislation, new work procedures, discuss systematic errors or problems that have arisen in the process of tax accounting, and resolve controversial situations.

The corporate tax control service may be involved in tax audits to provide oral and

<sup>2</sup> Составлен автором.

written explanations during the audit, and upon completion, take a direct part in preparing objections to the audit report.

Employees of the corporate tax control service, based on the volume of tasks assigned to them, must have extensive knowledge and be well versed in accounting, tax, civil and labor laws. They must constantly maintain a high level of their professional knowledge and skills, and the business entity must take this into account when organizing the work of employees of the corporate tax control service. In our opinion, the creation of a system of corporate tax control requires the participation of specialists from related services (planning, financial, legal, accounting).

Analysis of tax accounting information systems in order to implement the function of control over the management of tax obligations assumes that the defining characteristic of the information products used is their ability to reduce labor and material costs. As for the organizational structure, the need for a separate tax group - the corporate tax control department directly depends on the size of the organization. "Foreign companies usually have tax departments as separate structural units whose task is to organize and maintain tax accounting on the basis of management accounting." In addition, one of the main functions of such a group is tax risk management" [2].

The experience of the Republic of Uzbekistan indicates that the functions of corporate control of tax obligations are often assigned to one or two people who are competent to assess business transactions from a taxation perspective. Management of tax obligations can be carried out even in the absence of a corresponding department in the organization in the form of distribution of its functions between various structural divisions: financial department, accounting department, legal department, audit service, etc. [3].

Thus, due to the absence of certain functions (for example, planning and control) or the presence of only some elements of these functions for managing tax obligations, business entities of the Republic of Uzbekistan are organizationally often limited only to the presence of employees authorized to carry out tax accounting.

If the overwhelming majority of domestic business entities involve third-party organizations to improve the system of management and control of tax obligations only sporadically, then the experience of foreign companies indicates the opposite. According to a study conducted by KPMG specialists, "among 753 companies from 18 different countries, 68% of respondents systematically resort to the help of third-party specialists - they delegate part or all of their tax functions to consulting companies. Among tax departments, leading importance is given to the function of tax accounting and tax payment; less attention is paid to the analysis of business transactions at the stage of their implementation. Accordingly, the amount of time spent by companies on performing these functions is distributed" [4].

Some companies (mostly Asian) are ready to increase the staff of tax departments, considering this a less expensive way; American and European organizations have chosen an intensive path - they redistribute the workload by increasing the competence of their employees.

In connection with the introduction of transfer pricing legislation in the Republic of Uzbekistan in 2021, a number of companies may need to create an additional system for planning tax obligations, which will help reduce the emergence of tax risks.

For the corporate tax service of a company, competent tax administration is very important, which goes far beyond tax control, including methodological support and support of business processes, as well

as protection of the company's interests in tax disputes during objections to audit reports, in courts, etc.

Let us outline the main problems that business entities may encounter when organizing a separate corporate tax service:

- insufficient internal resource;
- the corporate tax service is not involved (or weakly involved) in the process of making management decisions;
- conflict of interests of individual employees, services, divisions;
- lack of process automation.

To organize a corporate tax service in accordance with the specified goals, it is necessary:

- identify problematic bottlenecks;
- analyze business processes, develop and describe local acts (participants in tax business processes, sequence and deadlines for implementation);
- make changes to existing local regulations of an economic entity.

The management of a business entity is responsible for the development, implementation and effective functioning of the corporate tax control system. At the same time, it is possible to implement it either by a specially created corporate tax control service operating within the company, or by assigning its functions to specific employees of the organization [5].

As a result of the changes made in the business entity, it becomes possible to prevent the emergence of tax risks and make maximum use of tax reserves (full use of the benefits and tax preferences provided by the legislation on taxes and fees). An independent corporate tax service allows you to improve the quality and depth of analysis of tax risks and reserves compared to external tax consultants and comply with new legal requirements.

We have identified the following participants in the system of corporate tax control in business entities:

- the tax department (tax policy, corporate tax service) is a key expert in the process of planning tax obligations, since specialists from this particular structural unit are able to expertly assess the consequences of a particular decision made in tax planning. This department is the managing element of the corporate tax control system, which initiates all issues related to planning, tax accounting and control of tax obligations, influences and manages other participants;

- The economic planning department is also an active participant in corporate tax control. Its goal is to form a tax budget (plan) with the involvement of the necessary and interested structural units of the organization;

- accounting service (accounting), which maintains the accounting and information base necessary for tax planning;

- legal department, ensuring competent registration and re-registration of contractual relations with counterparties, taking into account the emerging tax budget (plan) of taxes;

- financial department, which takes into account outgoing and incoming tax flows in the payment budget (plan).

Western authors propose the creation of a special unit of corporate control - a corporate tax service, responsible for ensuring compliance with tax legislation, setting up and maintaining tax records, attracting tax consultants and applying recommendations on tax planning, providing tax reporting and interacting with tax authorities [2].

In practice, several options for the structure of the corporate control service are possible. Traditional in the practice of the Republic of Uzbekistan is the creation of a service on its own, accompanied by the hiring of specialists with the required qualifications or training of existing employees. A separate structural unit may be organized or an official may be assigned. The list of functions and tasks assigned to the service is determined in a

local regulatory document - for example, in a regulation, and is indicated in employment contracts and job descriptions of department employees. It is possible to attract specialists from the head office of holding companies if the holding already has such a service.

Another possibility is to invite external specialists - co-sourcing of corporate control (from the English co-sourcing), which is becoming increasingly important due to the increasing demands of companies for highly qualified resources. This implies the division of functions for performing any business process between company personnel and external specialized performers on a project basis, based on requests received from the customer.

The third option for organizing a corporate control service is outsourcing, when the company has only an audit committee and a director of corporate control, who collaborate with a team of external specialists and receive final reports from them.

What functions these will be, and to what extent they can be performed, is determined by the service agreement between the contractors [6].

When organizing a corporate control service or switching to a more effective option, it is important to consider how much you can reduce the costs of creating and maintaining this service, while at the same time ensuring maximum coverage of all risks. The choice of the optimal option should be accompanied by an assessment of the pros and cons of a particular type of organization of the corporate control service.

Let us highlight the main functions of the corporate tax control department:

1. Monitoring the effectiveness of corporate tax control procedures. Establishing the necessary tax accounting and corporate tax control systems is the responsibility of management, and the corporate tax control function is usually assigned the responsibility of reviewing

these systems, monitoring their effectiveness, and making recommendations for their improvement.

2. Investigation of financial, management, legal and tax information, which includes a review of the means and methods used to collect, measure, classify and report on this information, as well as specific inquiries regarding its individual components, including detailed testing business transactions, accounting and tax registers and other procedures.

3. Monitoring economy, efficiency and effectiveness, including non-financial controls of the auditee.

4. Monitoring compliance with the legislation of the Republic of Uzbekistan, regulations, as well as internal management requirements.

5. Identification and prevention of tax risks, implementation of measures to minimize them.

6. The corporate tax control service should be involved during tax audits to provide oral and written explanations to inspectors during the audit, and upon completion, directly prepare objections to the audit report.

Thus, employees of the corporate tax control service must have broad competencies in accounting, tax, civil and labor laws, and constantly maintain their high professional level [7].

Often, the corporate control department in many companies is viewed as an element that "interferes" with functional work. In our opinion, it is necessary to consider this function as a "partner" function, which can provide information about valuable experience or innovation from another function or from global practice.

In terms of risk prevention, the corporate tax control department in the tax risk management concept includes several components:

- identification and qualification of the economic and legal content of tax risks;
- formation of an organizational framework for the implementation of

preventive measures to reduce the possibility of risk events in the activities of an economic entity, taking into account modern requirements and prospects for changes in tax legislation;

– identification of the most problematic areas of economic activity that require special attention while complying with the rules and conditions for the formation of tax obligations;

– reduction of transaction costs;  
– development of recommendations on appropriate actions for the taxpayer.

The goals pursued by the corporate tax control department in relation to the prevention of tax risks are:

– in ensuring confidence in the completeness and timeliness of reflection of business processes in accounting and tax accounting;  
– optimal forecasts of the level of tax liabilities;  
– legality and effectiveness of tax planning methods;  
– economic feasibility of carrying out business transactions;  
– assistance in identifying potential tax violations;  
– protection of the legitimate property interests of an economic entity.

The tasks of the corporate tax control department of a business entity, in relation to the set goals, include:

1) organizing constant and periodic monitoring of the compliance of financial and economic transactions carried out in the organization and its structural divisions with the requirements of tax legislation;

2) control over the main areas of financial and economic activity that form the tax bases in the context of certain types of taxes;

3) ensuring sufficient confidence regarding the reliability of tax reporting indicators, compliance with procedures for its preparation, as well as compliance with accounting, tax and management accounting requirements;

4) carrying out an analysis to identify significant aspects affecting the reliability of the tax planning measures applied;

5) creation and implementation of control procedures to minimize or eliminate the risks of business processes, taking into account the requirements of tax legislation or clarifications of its individual provisions by authorized bodies;

6) development, implementation and maintenance of a system for monitoring risk situations in accordance with trends in the development of law enforcement practice;

7) control over compliance of transaction terms with the interests of the taxpayer;

8) identification of ineffective and irrational (from the standpoint of ensuring the property interests of the taxpayer) methods of accounting for the tax base, conditions for the application of tax preferences;

9) compliance with an acceptable level of completeness and accuracy when preparing primary documents, consistency and reliability of the information contained in them.

A special unit of corporate tax control (corporate tax service) is responsible for ensuring compliance with tax laws, developing and applying recommendations for tax planning, engaging tax consultants and interacting with tax authorities [8].

Thus, corporate tax control, being a function of managing tax obligations, can only be implemented in business entities with a high level of corporate culture, subject to the interaction of owners, top management, the corporate tax control service, and an independent audit organization.

The use of the developed recommendations by business entities will make it possible to make maximum use of tax reserves (full implementation of benefits/tax preferences provided by the legislation on taxes and fees) and prevent the emergence of tax risks (preventing the

identification of risks by external controllers/tax authorities).

An effective system of corporate tax control should be focused on upcoming events that can be influenced, that is, be risk-oriented.

Each corporate tax control procedure must meet the requirements:

- to the disclosure of risks and control points that prevent them;
- to functional and cross-functional alignment;
- to direct participants and responsible persons;
- to the selection and regular monitoring of key indicators of procedure execution.

Spot checks of the execution of the described controls are carried out on a regular basis by both direct participants in the procedures (responsible for the procedure), responsible functional managers, and the corporate tax control service. Identified comments are recorded and those responsible for correcting them are assigned. By regularly monitoring the status of identified comments and carrying out additional monitoring based on their dynamics, it is possible to identify areas requiring "increased attention" and provide recommendations to the relevant functional managers.

### **Conclusions and offers.**

1. Currently, in most business entities, the management of tax obligations is limited to their planning and tax accounting, which, due to their functional role in the management process, are not always able to provide a control function.

2. The function that completes the process of managing tax obligations is control, which is a process carried out by an economic entity to achieve strategic tax goals determined by planning tax obligations and solving current problems carried out within the framework of their tax accounting. Moreover, planning of tax obligations must comply with the law and its own internal policies regarding taxation procedures, and tax accounting must

If the indicator of newly identified tax violations exceeds the indicator of corrected errors, if the indicator of the amount of identified risks from internal sources (full-time employees) does not financially cover external sources (preliminary claims of tax authorities), if the indicator of the amount of won tax disputes does not financially cover the amount of the claim by decision of the tax authority and/or the dynamics of indicators does not improve, which means that the goals have not been achieved and it is necessary to return to the description of risks and control points for a more serious analysis.

To summarize, we note that the reform of corporate control instruments in business entities is due to the interregional differentiation of taxation conditions, the high level of heterogeneity of the economic space, the instability and inconsistency of the existing tax system, the lack of a unified approach in developing the concept of corporate tax control, the use of several tax regimes by business entities, and the tightening of rules tax administration [9]. In the current conditions, one of the solutions to improve the efficiency of business entities may be the methodology for conducting corporate tax control, enshrined in the corporate standard [10].

ensure the proper level of formation and fulfillment of tax obligations.

3. The optimality of tax obligations is determined by the measure of the effectiveness of coordinating the economic interests of the state and business entities, which is fully realizable only if the business entity has a system of corporate control over the fulfillment of tax obligations and corresponding analytical tools that can significantly influence their amount. It should be noted that in the economic and legal literature, along with the term "corporate control", such a concept as "internal control" is also used. Moreover, in contrast to the term corporate control, which is not disclosed at the legislative level, current regulations contain legal

definitions of the concept of "internal control".

4. The standard for organizing a corporate tax control system is focused on creating unified approaches, increasing the efficiency of the control function, and reducing the number of violations of tax legislation. Focused on preventing illegal and irrational (from the point of view of respecting the interests of an economic entity) operations at the initial stages of making a management decision, it involves the systematic achievement of set goals, and its effectiveness can only be discussed if reliable information is received that the

goals and objectives set before the economic entity, achieved rationally and economically and correspond to the planned results.

5. The use of this standard will make it possible to methodologically and organizationally ensure the effectiveness of corporate control and will contribute to the optimization of tax payments, timely and complete execution of budget assignments by business entities, and will also increase the social responsibility of business to the state for the fulfillment of their tax obligations.

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# ISSUES OF ORGANIZING INTERNAL CONTROL OF FULFILLMENT OF TAX OBLIGATIONS OF ENTERPRISES

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**Annotation.** The article discusses the economic essence, the need and objectives of organizing corporate control over the fulfillment of tax obligations by business entities, its methodological support, internal and external factors taken into account in the process of developing a corporate standard for this function, the feasibility of using tax management tools in the methodological support of this special type of accounting and analysis, tools have been developed to ensure the completeness, objectivity and reality of the obtained results of one of the effective methods of corporate tax management - internal control.

**Keywords:** taxpayer, tax obligations, control over the fulfillment of tax obligations by business entities, corporate control, tax management, corporate tax management, corporate standard for monitoring the fulfillment of tax obligations.

**Introduction.** It is well known that in the "Concept of integrated socio-economic development of the Republic of Uzbekistan until 2030", approved with the Decree of the President of the Republic of Uzbekistan No. DP-5614 of 01/08/2019, special attention is paid to the issues of ensuring the financial stability of enterprises using tax management tools [1].

Taxes, as built-in regulators of the state's fiscal policy, are tools of motivation and external restrictions on the financial results of business entities and the profitability of their capital. Optimization of the tax system, ensuring the coordination of the economic interests of participants in tax relations, determines decisions that determine the positive vector of fulfillment by business entities of their tax obligations.

Institutional imbalance and insufficient constructiveness of mechanisms of inter-subject interaction in the field of tax policy determine the need to improve models of intra-corporate tax regulation and the formation of effective tools in the field of monitoring the fulfillment of tax obligations by business entities. Accordingly, a detailed consideration of the tax segment of corporate control is

necessary. Such an analysis will also serve to continue research in this scientific area and will contribute to the effective implementation of an effective model of the system of tax relations between business entities and the state.

The national economic significance and scientific relevance of the topic of this scientific article are determined by the experience of recent years, which has proven the futility of the practice of episodic attention to the control of their own tax obligations on the part of business entities and has revealed the objective need to improve the existing tools of the control mechanism.

There is an urgent need to modernize existing methods and develop new control and analytical tools (technologies), separating them into a separate independent area of financial science and the practice of corporate control of business entities, systematizing the accumulated scattered theoretical knowledge and fragmentary analysis of practical experience in order to minimize the tax risks of business entities.

The above problem is typical, as a rule, for large and medium-sized

businesses, because in small businesses, the costs of creating a full-fledged control system may exceed the benefits of its implementation. Separately, we note that the study of the problems of state (external) control of tax obligations at the macro level is also extremely relevant, but is the subject of a separate scientific study.

Thus, the unresolved nature of a number of key problems of the organization, the need for the functioning and development of a control mechanism in the sphere of interaction between the state and taxpayers determine the development of new theoretical and methodological foundations for the development of these relations. The importance of the problem under consideration, its practical significance, the need to form a new model and tools for corporate control over the fulfillment of tax obligations by business entities give the topic of this scientific article increased relevance.

**Main part.** The function that completes the process of managing tax obligations is control, which is a process carried out by an economic entity to achieve strategic tax goals determined by planning tax obligations and solving current problems carried out within the framework of their tax accounting. Moreover, planning of tax obligations must comply with the law and its own internal policies regarding taxation procedures, and tax accounting must ensure the proper level of formation and fulfillment of tax obligations. At the same time, an effective system of corporate tax control should be focused on upcoming events that can be influenced, that is, be risk-oriented.

Any management decision entails certain risks, and in this regard, one of the control functions is to anticipate future risks in an uncertain business environment. To ensure full control over compliance with tax obligations within an economic entity, a systematic organization of corporate tax

control is advisable. Developed on the basis of standards accepted in world practice, it will allow not only to evaluate the quality of its elements, but also to take into account the specifics of a business entity [2].

Business entities, when carrying out several types of activities simultaneously, must successfully combine special tax regimes and the general taxation regime, which significantly complicates the maintenance of corporate tax control. In this regard, the task of developing an effective methodology for its implementation is becoming urgent; The efficiency of business entities depends on the solution to this problem. To achieve the set goals and solve management problems, it is necessary that the internal regulatory document - the standard for conducting corporate tax control - reflects the deadlines and contains a list of necessary documents reflecting the features of sampling, methods and control tools.

The control process should be carried out multifaceted: on the one hand, it should be based on standardization, which involves the business entity constantly measuring actual results and recording deviations from previously established standards, and on the other hand, it should focus on the process of monitoring the progress and quality of implementation of the adopted management decision and technologies for assessing achieved results. If, during the implementation of planned activities, significant deviations from the main indicators are identified, the results obtained during monitoring can serve as the basis for the head of the organization to make management decisions.

In the Tax Code of the Republic of Uzbekistan, issues of methodology, methods and organization of corporate tax control are not addressed at all, since they are transferred to the competence and area of responsibility of the business entities themselves.

Disclosure of the content of the corporate tax control system and the methodology for its organization are impossible without a clear formulation of its subject, object, subject, legal status, objectives and principles of control.

Analysis of the list of subjects of tax control allowed us to come to the conclusion that most of the authors, including the legislator 220, limit the range of objects under consideration only to "the system of tax authorities or bodies that have the powers of tax authorities," while emphasizing that the subject of corporate tax control should be a control body (for example, a corporate tax control service) independent of the accounting department of a business entity.

Facts of economic activity that have tax consequences are considered as an object of corporate tax control of business entities.

The subject of corporate tax control is the tax obligations of business entities.

The determination of the legal status of corporate tax control is not fixed by law, but can be regulated by the internal standards of business entities.

The objectives of corporate tax control are:

- conducting a systematic analysis of the impact of changes in the external environment on the tax obligations of a business entity;
- regular updating, testing and certification of the control system;
- monitoring of comments and plans for their elimination;
- identification and documentation of tax risks and their control.

The system of corporate tax control of a business entity is based on the following principles (Table 1). Their implementation allows us to ensure continuity, independence, consistency and precautionary nature of corporate tax control of business entities.

Table 1

**Principles of the system of corporate tax control of business entities<sup>\*3</sup>**

PRINCIPLE	CONTENT OF THE PRINCIPLE
НЕЗАВИСИМОСТИ	An employee or corporate tax control department is directly subordinate to the management of a business entity and should not be associated with or dependent on accounting or any other financial service
PLANNES	The business entity must develop regulations, compliance with which is verified during planned control activities
REGULARITY	Control must be carried out systematically and on a regular basis.
OBJECTIVITY AND RELIABILITY	Elimination of subjective assessments and distortion of actual data
RESPONSIBILITY	Based on the results of control measures, penalties should be imposed on the guilty persons
LEGALITY	The need to comply with tax, civil and other legislation of the Republic of Uzbekistan.
COMPLIANCE WITH TAX SECRET	Tax accounting data is a tax secret
UNIVERSALITY OF TAX CONTROL	Control measures should cover all business processes that have tax consequences

<sup>3</sup>Compiled by the author based on research results

<b>UNITY</b>	The integrity and unification of corporate tax control is served by the corresponding standard
<b>TIMELINESS</b>	Control measures are carried out not only before preparing tax reports, but also during the tax (reporting) period
<b>DOCUMENTATION OF RESULTS</b>	Control activities are documented with relevant documents (for example, inspection reports)

A number of authors identify as “elements of the internal tax control system: subject, object, subject, legal framework, methods, procedures of internal tax control, stages of internal tax control, documents, information base” [3].

In our interpretation, the corporate tax control system consists of the following elements (Table 2).

Table 2.

### Elements of the corporate tax control system (CTCS) [2]

SYSTEM ELEMENTS	CONTENT OF SYSTEM ELEMENTS
<b>Means and methods control</b>	Commitment to common principles and ethical values Consolidation of supervisory functions Formation of structure, distribution of rights and responsibilities Commitment to the principles of professional competence Increased Accountability
<b>Tax risk assessment</b>	Identification of current tasks Risk identification and analysis Assessment of risks of non-compliance with tax legislation requirements Identification and analysis of significant changes Selection and improvement of control measures
<b>Control activities</b>	Selection and improvement of IT solutions in order to implement control measures Consolidation of tax policy and relevant regulations Using up-to-date information
<b>Information and communication</b>	Internal communication External communication
<b>Events Monitoring</b>	Carrying out simultaneous or separate assessment activities Assessing system deficiencies and eliminating them

The first element of the system is the means and methods of control. Management activities take place in a control environment, which includes communication and a set of actions of company employees vested with a number of powers in relation to the corporate tax control system established in the business entity. The assessment involves an analysis of the competence of employees, the degree of participation of the owner and (or) his representatives in the process of

managing the company, the level of competence and features of the management style of management, the type of organizational structure, the degree of vesting of employees with powers and responsibilities, features of personnel policy. The quality of control is largely determined by the personal and professional characteristics of the employees involved in this process, and not by the content of organizational and legal documents, regulations and reports:

the presence of a detailed regulatory framework cannot fully compensate for the lack of competence or professional knowledge. In this regard, the need to establish strict qualification requirements and monitor the compliance of employees responsible for performing supervisory functions with them is obvious.

Only a detailed, systematic personnel policy will make it possible to competently select qualified specialists, develop a system of measures that will help develop motivation and stimulate employees, which in turn will significantly reduce the number of unintentional errors. Another factor in the control environment is the competence and work style of management: employees of various financial services, like no one else, understand that in most cases the level of "CTCS" in a business entity largely depends on the manager's position regarding the criteria for optimal tax burden on a business.

The most important factor in the effectiveness of CTCS is the honesty of employees, since sometimes employees violate the rules of corporate control not by mistake, but deliberately. Accordingly, it is necessary to cultivate high ethical and behavioral standards in business entities, and first of all, management must set a personal example. In addition, a corporate code of conduct can be adopted and communicated to all employees.

The second element of the CTCS system is the identification and assessment of tax risks. Since the environment in which the life of an economic entity takes place is subject to constant changes, there is a high probability of various risks arising that must be foreseen and prevented in a timely manner, taking into account their possible consequences. They identify risks associated with the influence of the external environment, for example, associated with changes in legislation, etc., and risks associated with transformations of the internal environment, for example, due to personnel renewal, introduction or change of information and communication

systems, rapid growth of the company, the emergence of new technologies, innovative approaches to management activities, introduction of new products, types of services, reorganization of the company, expansion of areas of activity abroad, etc.). Let's assume that management has set a task to reduce the time frame for VAT refunds on export transactions from four months to three. At the same time, the head of the structural unit providing corporate control understands that at present, documentation interaction with suppliers is not yet sufficiently streamlined and there is a risk of failure to achieve the assigned task in terms of timing and quality of preparation of invoices and other documents. Therefore, one of the possible solutions can be considered making the necessary additions to the existing contractual policy of an economic entity regarding the introduction of a dependence of the terms of payment of invoices provided by suppliers on the terms and quality of the provided accompanying documentation. We believe that in this case the possibility of achieving the set goal is obvious. The key point in the implementation of this area of activity is not only the identification and identification of risks, but also the detailed development of ways to minimize their occurrence, monitoring and annual reassessment.

The third element in the CTCS system is control measures or systematic control actions. Control methods in the broad sense of the word include procedures and activities that clearly demonstrate that the manager's orders are carried out in accordance with the instructions. Monitoring internal regulations governing document flow, as well as carrying out a system of control measures developed by the organization's management, will ensure not only strict compliance with regulations and provisions governing accounting policies, but also the safety of property, high quality documentation and information support

necessary for effective management of the company, increasing production levels. Of course, the priority in choosing a control technique is determined by the expected risks that may arise in a certain area. Thus, in the activities of a tax department employee responsible for maintaining tax records, there may be a risk of accepting for tax accounting for income tax expenses that are not accepted or exceed the limit. This risk can be reduced thanks to the control procedure - systematic reconciliation of tax accounting registers with the templates "Expenses not accepted for tax purposes" and "Normalized expenses". The introduction of special settings in accounting programs will significantly reduce the risk of possible errors. However, when working with these programs, your own risks may arise: unauthorized access, incompetence of personnel, failures in the program, etc. To minimize them, it is possible to install protection against unauthorized access, improve the qualifications of personnel, and timely update the software.

The fourth element of the system is called "Information and Communication" (information system). This component of the CTCS significantly influences the work of the corporate tax service, since currently business entities are required to be more transparent in relation to taxes paid - "tax transparency". As Western experts note, "an advanced corporate tax service should have a unified communication plan that answers the following questions: with whom it is necessary to exchange information, what both parties want to receive from each other during interaction, how information will be exchanged, and the regularity of contacts" <sup>231</sup>. The proposed plan should be considered as an internal document of the corporate tax service, which standardizes and unifies the processes of information exchange between this service and external and internal stakeholders.

As the fifth element of the corporate tax control system, we will consider the

activities carried out as part of monitoring that controls the process of assessing the functioning of the system over a certain period. The system of measures also provides ways to ensure administrative control over the work of specialists. Among the methods, it is necessary to highlight a phased assessment of the quality of the organization and the effectiveness of the functioning of controls, the timeliness of the implementation of necessary corrective measures that are adapted to constant changes in conditions, checking the quality of fulfillment of management requirements established by the company's internal documents, the availability and quality of supporting information received from third parties. It is the responsibility of management to constantly monitor the effectiveness of the CTCS and make changes if necessary. Since tax conditions are constantly changing, the key to effective tax system management is the ability to respond to changes in a timely manner and successfully manage transformations [4].

The result of corporate tax control is a report in which each audit object is described in detail, the shortcomings and violations identified during the tax accounting process are shown, and recommendations are given for eliminating shortcomings and correcting errors within a specified time frame. If the corporate tax control system has proven itself well, then a report drawn up based on its results and containing an assessment of the degree of its reliability, a description of previously identified shortcomings in the functioning of the corporate tax control system, constructive proposals for its improvement, can be offered to external auditors during a tax audit. If necessary, a corporate policy in the field of tax control can also be developed and measures taken to implement it into the internal environment of the business entity.

Using the proposed methodology, the formation of a corporate tax control system will enable business entities not only to

optimize a set of actions aimed at increasing their own financial resources, but also to regulate the size and structure of the tax base, which will ensure timely settlements with the budget in accordance with the requirements of current legislation, by influencing efficiency management decisions.

The use of the developed methodology will allow for effective verification of the correctness, completeness and timeliness of the calculation of tax amounts by establishing control procedures performed by responsible employees.

During corporate tax control, it is imperative to pay attention to the following control points:

- the degree of compliance with the current tax legislation of the Republic of Uzbekistan, local regulations, organizational and administrative documents, accounting policies for tax accounting;
- correctness and timeliness of recording all business transactions in tax

registers;

- correctness and completeness of documenting business transactions;
- correct reflection of income and expenses in tax accounting;
- correctness of preparation of tax reporting of the organization.

Corporate tax control organized in accordance with this methodology will help reduce the risk of errors in the formation and fulfillment of tax obligations; clear regulation of control actions will minimize the costs of its implementation through standardization of control processes in an economic entity.

The effectiveness of control and analysis of tax flows, income, expenses and risks of a company directly depends on the effective organization of the corporate tax control service. The more effective corporate tax control, the more tangible the results of its activities. "In absolute terms, the result of corporate tax control is the amount of money that the company managed to save due to its functioning:

$$R = Do - D1 \quad (1)$$

where

*R* - the result of the functioning of the corporate tax control service;

*Do* - losses (losses) in the absence of a corporate tax control service;

*D1* - losses (losses) under the current corporate tax control service.

But implementing a corporate tax control service requires certain costs. The business entity must receive an economic benefit and, at a minimum, justify the additional costs invested in creating the service:

$$E = R - C \quad (2)$$

where *E* – savings or losses (efficiency);

*C* - cost of CTCS.

It is obvious that the corporate tax control service will bring benefits only if the result of its activities exceeds the costs of its creation and operation:

$$E > 0, \text{ or } R > C \quad [5].$$

For an expanded assessment of the effectiveness of the corporate tax control service, Malyshkin A.I. suggests using the following indicators:

- "the amount of newly identified violations (*Vn*) to the amount of corrected violations (*In*):

$$K1 = Vn / In \quad (3);$$

- the sum of identified risks from internal sources (full-time employees) (*Rvi*), to the sum of risks from external sources (claims from tax authorities), (*Rv*):

$$K2 = Rvi / Rve \quad (4);$$

- the amount of won tax disputes (*Vns*) to the amount of the claim according to the

decision of the tax authority (Pno):

**K3 = Vns / Pno» [6] (5).**

If the values of these coefficients are positive for a certain reporting period, then the corporate tax control service is working effectively; if negative, vice versa. It is also important to study these coefficients over time: if the dynamics of indicators do not improve, then the goals have not been achieved and it is necessary to return to the description of risks and control points, both at the level of the entire function and at the level of individual procedures for a more detailed analysis.

The results of the assessment of the corporate tax control system allow us to reasonably determine the areas of necessary changes and create the basis for the introduction of best practices in this area:

- optimally distribute competencies (powers, duties and responsibilities) between levels of tax liability management;
- develop a system of regulations for the functions of managing tax obligations - planning, tax accounting, control;
- create or improve the efficiency of an existing unit that carries out corporate tax control (corporate tax control service, corporate tax service, etc.);
- develop and implement regulations and methods for the activities of departments exercising corporate tax control, etc.

The presented procedures for corporate control of income tax make it possible to compare data from analytical and synthetic types of accounting, to identify their relationship with the data of accounting (financial) and tax reporting. At the same time, the incomparability of controlled indicators indicates the unreliability of the reporting data.

In particular, for income tax, the following control procedures are identified as the main stages: study of accounting policies for tax purposes; analysis of the state of tax settlements with the budget; control of the correctness of the formation of the tax base (checking the

completeness, reliability and timeliness of recognition of the organization's income and expenses in tax accounting); reconciliation of taxable and accounting profits, as well as indicators of accounting (financial) statements and income tax returns.

The main control procedures for checking the status of income tax calculations include:

- "confirmation of the opening balance in the "Income Tax" account in order to identify unrecorded liabilities to the budget, including for previous periods;
- checking the correctness of calculations of the current income tax through an analytical check of the calculation of income and a detailed check of individual items of income (expenses);
- control of the correctness of reflection in the accounting accounts of updated calculations with the budget for income tax in previous tax periods, including based on the results of external tax audits and external tax audits carried out in relation to the business entity;
- control of income tax payments, which is carried out using a random selection of payment orders and data from reconciliation reports with information from tax inspectorates."

The greatest accuracy of control procedures for income tax is ensured by reconciliation of profits according to tax accounting data and accounting profit, as well as data from accounting statements and tax reports on income tax. The results of the reconciliation of taxable and accounting profits will allow the corporate tax control service to identify deviations and verify the accuracy of the calculation of the tax base for income tax.

**Conclusions and offers.**

1. In order to ensure tax transparency, social responsibility of business at the macro level, minimizing tax risks and consistent tax policy at the level

of business entities, the latter are recommended to organize corporate tax control, allowing them to optimize their tax obligations and minimize tax risks.

2. The methodology of corporate tax control is aimed at obtaining sufficient confidence that the activities of a business entity meet the requirements of: a) the efficiency and effectiveness of corporate tax policy, including helping to achieve the goals of tax transparency and ensuring the minimization of tax risks; b) reliability and timeliness of submission of tax reports to the tax authorities; c) compliance with tax legislation, both in the course of business transactions and in maintaining tax records.

3. The standard for organizing a corporate tax control system is focused on creating unified approaches, increasing the efficiency of the control function, and reducing the number of violations of tax

legislation. Focused on preventing illegal and irrational (from the point of view of respecting the interests of an economic entity) operations at the initial stages of making a management decision, it involves the systematic achievement of set goals, and its effectiveness can only be discussed if reliable information is received that the goals and objectives set before the economic entity, achieved rationally and economically and correspond to the planned results.

4. The use of this standard will make it possible to methodologically and organizationally ensure the effectiveness of corporate control and will contribute to the optimization of tax payments, timely and complete execution of budget assignments by business entities, and will also increase the social responsibility of business to the state for the fulfillment of their tax obligations.

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## SPECIFIC FEATURES OF MANAGEMENT IN SMALL BUSINESS ENTERPRISES

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**Abstract:** Since the development of small business is approved as one of the strategic goals of the national economy of Republic of Uzbekistan, study of the small business management issues becomes relevant today. In this regard, our article aims to discuss the features of management specific for small businesses in order to study best practices that can enhance small business growth. The different works of various researchers and specialists are observed regarding the topic of the study. management methods for running of small entities are reviewed. During the study, both advantages and disadvantages of small business management are observed in detail. And the series of modern software products are offered for small businesses which aim at facilitating business processes.

**Keywords.** Management, control, organizing, planning, small business entities, management methods, digital instruments, software products, effective management.

**Introduction.** Effective management of an enterprise is always considered as an important criterion for the efficiency of the business as a whole. Carrying out a competent management is especially important in modern market conditions, with existing market trends, increasing competition at the age of digital technologies, which reflects the relevance of the topic under consideration.

Effective management issues are of particular relevance in small enterprises. According to the world statistics, more than half of small businesses do not survive to two years, and only one in ten reaches ten years of age. The reason for this in most cases is ineffective management.

Financial success, mobility, new developments, quick responsiveness and job creation are all strengths of small businesses. However, its weak sides should also be noted. Organizing an own business is not a labor-intensive operation that requires large financial investments, if we consider the formal part of this procedure. In addition, freedom in choosing an occupation gives an entrepreneur the opportunity to work in any industry, regardless of education and experience.

But such freedom can lead to both success and failure.

More often small businesses fail because managers cannot cope with the ever-increasing demands of management as, in most cases, he is the only one in charge for the most of company's operations. Adapting to the rapidly changing external environment of a small business organization requires making quick and accurate decisions.

And this, in turn, determines the need for the organization to quickly adapt to new economic conditions, and it causes even to change the concept of small business and its management paradigm. All this reflects the significance of the topic of current work [1].

And so, the purpose of this thesis is to study the features of managing small enterprises and analyze possible ways to improve the efficiency of management activities.

Based on the goal, the following tasks were formulated:

- determine the essence and content of the enterprise management process and its features for small businesses;

- discuss the contemporary digital instruments of management at small business companies;
- study the types of management methods used at small businesses;
- analyse the pros and cons features of management at small business's enterprises;

**Literature review.** Small business has become an integral part of market economics. Its importance is quite high: small business has become an important link in the country's economy, it helps to solve the issue of employment, replenishes the state treasury through tax payments, and fills niches missed by large enterprises.

Many contemporary authors dedicated their works to the small business management issues in the current context.

According to Soldatkina O.V., specialist in management sphere, claim that all the managers complete the same tasks which are: planning, organizing, motivation and control. Planning is the main management function on which all other functions depend. The planning manager outlines the organization's goals and determines the best ways to achieve them, on which all activities of the enterprise should be focused.

The task of the organizing function is to form the structure of the enterprise, as well as to provide it with everything necessary for proper operation – human resources, materials, equipment, premises, funds, etc. Once the plan has been drawn up, the task now is to create real conditions for achieving the intended goals.

Motivation is a function of management, the purpose of which is to create incentives for the employee to work and encourage him to work with full dedication.

A manager's job is to get to know people, observe them to determine what active needs drive them.

Control is a management function, the task of which is to quantitatively and

qualitatively assess and record the results of the enterprise. The main tools for performing this function are observation, checking all aspects of activity, accounting and analysis [2].

Based on the works of Alborova M.B., it can be stated that in small business companies the process approach has gained widespread acceptance. In this case, management is presented as a process consisting of sequential execution of functions.

Planning process of the management function answers three main questions: the current state of affairs at the enterprise, its objectives, ways to achieve these goals. The organization process includes two directions which are formation of a structure of authority and coordination of the production process, employee work, regime, work order at the enterprise. Motivation is carried out as follows: firstly, identifying employee needs, then giving them the opportunity to satisfy needs through the work they do. Control includes the following steps: development of standards; measurement of actually achieved indicators, comparison with established standards; identifying the causes of discrepancies; determination of actions to clarify plans.

The process approach indicates the main general stages of management and makes it possible to select stages for a specific company separately [3].

Zetkin A.S. points out that the main distinguishing feature of small business management is high responsibility in making management decisions, which naturally determines the quality of the company's management, the level of qualifications of manager and efficiency [4].

A distinctive feature of small business management, by the opinion of Kuramshina K.S., is the presence of little time for making decisions, as well as not a very large amount of money at the disposal. All this is imposed by external factors, in the context of a modern market economy [5].

In conclusion, the literature provides strong evidence for the importance of studying the management aspect of small businesses as the main factor for growth and development.

**Research methodology.** In order to study the issues raised in this particular article, to explore in more detail the specific features of small business entities' management in contemporary world of fast-changing economic conditions and digital area various methodology types are used. The methodology of this study consists of comparative analysis of research, observation method, method of deduction, theories of foreign and national experts, as well as an analysis of world experience.

**Analysis and Results.** As it is widely known, small business enterprises are quite important for the development of a

government's economy because of their flexibility factor. The level of development of small businesses is used to estimate the ability to adapt to the changing economic situation in the country [6].

In developed countries small business play a significant role in developing and expanding the country's economy. For instance, in the USA the activities of small and medium-sized businesses provide more than 60% of country's GDP, and the share of the population working in small enterprises is more than 50%. In Italy, 80% of the active population are engaged in small businesses. So, the small business's role in national economy is impossible to underestimate.

Thus, the management in such types of companies should be considered in a broad context [7].

FACTORS OF PRODUCTION	
It refer to the inputs one needs to make or produce a good or service	
4 FACTORS OF PRODUCTION?	
LAND	LABOR
<ul style="list-style-type: none"> <li>▪ It is broad term that includes all natural resources</li> <li>▪ Includes both renewable or non renewable</li> <li>▪ Earning is in the form of rent</li> </ul>	<ul style="list-style-type: none"> <li>▪ It is individual's physical &amp; mental efforts to make product/offer services</li> <li>▪ It can be skilled/ unskilled</li> <li>▪ Earning is in the form of wages</li> </ul>
CAPITAL	ENTREPRENEURSHIP
<ul style="list-style-type: none"> <li>▪ Capital stands for money as well as capital goods</li> <li>▪ Capital goods are used in production of goods</li> <li>▪ Earning are in form of interest</li> </ul>	<ul style="list-style-type: none"> <li>▪ This factor collects, control &amp; manages all other factors of production to come up with product/service</li> <li>▪ Profit is reward for entrepreneurs</li> </ul>
IS TECHNOLOGY 5 <sup>TH</sup> FACTOR?	
<ul style="list-style-type: none"> <li>❖ Though technology isn't 5<sup>TH</sup> factor officially, many consider it to be one</li> <li>❖ It plays important role in coming up with product or service</li> <li>❖ Helps an entrepreneur to make better decisions</li> <li>❖ Total Factor Production is a measure of technology &amp; investors see it as ingredient that drives economic growth of a nation</li> </ul>	

Picture 1. Factors of production:financemanagement.com

So, the management is the ability to achieve goals by directing the work and intelligence of employees and creating motivation for the behaviour of people working in the organization. Awareness of the role of management coincides in time

with the identification of entrepreneurial ability as an important unifying factor of production. Factors of production are the resources that are necessary to carry out the production process (labour, capital, land and other natural resources,

information) which are presented at Picture 1 [8].

The specificity of successful entrepreneurship in small business lies in the multifaceted activities of a businessman who takes the risk of opening and running his own business and is ready to be responsible for the results.

The entrepreneur (who is also the owner) is simultaneously a manager, economist, marketer, financier, production worker, lawyer and must be able to make decisions independently, taking into account each of the listed roles. If the personal and professional qualities of an entrepreneur meet the requirements for a manager, then he can successfully perform the functions of a manager and be an entrepreneur.

Otherwise, the entrepreneur, being the owner transfers management functions to a professional manager. World practice confirms that the number of people inclined to entrepreneurship does not exceed 7-8% of the number of workers.

Small businesses' features are very diverse. It varies overall a number of factors, and each of them influences to the features of management. Among these factors - size of the enterprise, number and composition of employees' characteristics, form of ownership, branch of activity, volume and assortment quality of products and services, organizational structure of the enterprise, features of demand and consumption, production quality and services provided.

In small enterprises with a small number of employees, (up to 15-20 people) there is often no special manager; subdivision, and the management itself is carried out at the elementary level and includes accounting, monitoring the profitability of business activities, work management. Enterprises, employing up to 70 people have a special unit capable of managing the economy in an organized manner. Technology is being practiced management of production, sales, labour and finance [8].

The implementation of management functions and principles is carried out through the use of various methods which are the following: administrative, economic, social-psychological methods.

Administrative methods. They are focused on such motives of behaviour as the perceived need for labour discipline, a sense of duty, a person's desire to work in a certain organization, etc. These methods of influence are distinguished by the direct nature of the influence: any regulatory or administrative act is subject to mandatory execution. Administrative methods are characterized by their compliance with legal norms in force at a certain level of management, as well as with acts and orders of higher management bodies.

Economic methods are used to provide material motivation for entire teams, as well as individual employees. Economic methods are developed based on economic activity.

Social-psychological methods. Sociological methods play an important role in personnel management; they make it possible to establish the purpose and place of employees in the team, identify leaders and provide their support, connect people's motivation with the final results of production, ensure effective communications and conflict resolution in the team.

Psychological methods play a very important role in working with personnel, since they are aimed at a specific personality of a worker or employee and, as a rule, are strictly personalized and individual. Their main feature is the appeal to the inner world of a person, his personality, intellect, feelings, images and behaviour in order to direct the internal potential of a person to solve specific problems of the enterprise [9].

In addition to abovementioned methods, there are modern small business management tools as well which help companies to switch to digital transformation mode. Modern small business management tools include a large

number of advanced technologies; the most common of them are:

1. Customer relationship management tools. CRM programs can track almost every business detail that occurs between a company and its customers, from their billing address to their preferred delivery day. CRM systems were first developed for large businesses with large sales departments, but now these systems are also available for small businesses.

2. Cloud collaboration tools. Over the past decade, businesses have realized that it is easier and cheaper to store the information they need to run their business online than on their own servers. This use of the Internet has become known as "cloud computing" or simply "cloud storage". Use Gmail for email or store files on Google Drive, means that the company data is already in the cloud. Quickbooks offers accounting software that you don't need to install on your computer, it has a cloud version.

3. Electronic invoicing tools. Electronic invoicing tools can be used from a computer, tablet or smartphone, and

many are cloud-based, such as online checkout. This allows employees to send an invoice from the work site at any time, which reduces the time spent interacting with contractors. Electronic invoicing tools offer a variety of options for small businesses and allow customers to send payments directly to the bank or through a specialized electronic payment system.

4. Social media management tools. Today, social networks are one of the platforms for promoting company products, finding new customers, increasing awareness and monitoring demand. There are many free or low-cost social media management tools available, such as Hootsuite and Buffer. Many of the best social media management tools are free at the usage level and most common in small businesses [10].

Moreover, in order to make the process of small company's management easier and more structured, researchers Prigunova M.I. and Tumakov I.K. made a classification of the most common software products for small businesses with the possibility of obtaining a free or shareware trial version represented at Table 1[11].

Table 1.

#### Software products for small businesses

Name	Description	Price
Asana	Asana is one of the important tools for small businesses. It is used to focus on the goals, projects and operational tasks of a business that is in a growth stage. With this digital product, all tasks, regardless of their size, can be managed in one place	0 - \$30.49 per month (\$24.99 per user per month if billed annually)
Trello	This program allows to work collaboratively with teams, helps visually organize and prioritize team projects. The program has a user-friendly interface.	0-17.5 \$ per month.
Rodeo Software	Rodeo Software is a project management tool designed to help small businesses optimize their profits while working efficiently to deliver projects on time. It offers all the features you need to manage projects	From \$29.99 per month per user (free trial)

#### MixMax

without the complexity (and cost). The tool has a simple interface that is easy to navigate even for those who are not technically savvy. It includes features such as budgeting, time tracking, task lists, and reporting that help you plan and execute projects efficiently and effectively.

MixMax is a browser plugin that helps track conversations, schedule emails, and use sequences and reminders.

From \$49 per month per user (14-day free trial).

#### Automate.io

Automate.io allows to connect various cloud applications that entrepreneurs use - marketing, sales, payments, web forms, collaboration, email and automate routine tasks. One can create simple, one-to-one integrations or workflows from multiple applications. Automate.io supports - Google Apps, Slack, Trello, Salesforce, Pipedrive, MailChimp, Infusionsoft, Zendesk, Quickbooks and more than 50 other popular applications

0-199 \$ per month. There is a free trial version.

The implementation of digital platforms and business methods can provide the basis for sustainable competitive advantage by reducing costs and improving quality. However, the disinterest of company leaders in the transition to a digital format and the lack of money for the implementation of new technologies may continue to hinder their development.

**Conclusion and offers.** To conclude, a number of factors have a significant impact influence on the methods, forms and style of personnel management in a small company. The task of the manager (head of the company) is to, taking into account the totality of specific factors of a particular enterprise, determine the optimal management system in order to achieve success.

During the study it was found out that there are various features related to only

small business entities. Here are some of them

From the point of view of managing a small enterprise, due to the small size and other features, management in small businesses is much more efficient than large enterprises, which gives good competitive advantages in the market. In other words, small businesses have the opportunity to make more flexible and responsive management decisions. Compared to large enterprises, small businesses have a simplified decision-making structure, and this makes it possible to quickly and flexibly respond to market changes. In particular, it is relatively easy to quickly extract funds from one type of business and transfer them to another in small business enterprises [12].

Small companies may focus primarily on the regional market. Small businesses are ideally suited for studying the wishes,

preferences, habits and other characteristics of the local market.

Small businesses are able to perform auxiliary functions in relation to large manufacturers. Large firms decentralize the production process, transferring its phases to small enterprises.

To add, along with advantages in management of small businesses there are some disadvantages as well. Small amount of capital and difficulties in finding investors reduce opportunities for development and growth. Banks and potential investors are more willing to provide loans to large, long-established companies.

The next challenge for small company is the poor qualifications of the manager. More often the manager, often the owner, single-handedly manages all areas at once. This increases the likelihood of errors occurring which creates an additional obstacle for the company.

Small businesses are more exposed to higher level of risk during a crisis due to their small capital under control in comparison with big corporations [13].

The study suggests that the government takes a front line in supporting and creating a favourable environment for the management processes in small businesses. Creating favourable operating conditions for the small companies' management, from one side, will help businesses prosper, from another point government may increase its GDP capacity. This can be named as Win-Win situation, since it is a mutually beneficial cooperation between government and business entities [14].

Overall, management in entrepreneurship involves the use of a variety of specific techniques and methods that provide justification and adoption of rational management decisions. The combination of these methods and techniques, specific to each business, constitutes the manager's special style and methodological apparatus.

In order to obtain maximum results, management must create decent working conditions and moral and psychological conditions in which employees would be comfortable and pleasant to work.

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## THE CONSTITUENT ELEMENTS AND THE NEED FOR STATE REGULATION OF SMALL BUSINESS AND PRIVATE ENTREPRENEURSHIP

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**Abstract.** The article analyzes the importance of small business and private entrepreneurship in the sustainable development of the country's economy and in meeting the endlessly growing needs of the population. the need for state regulation and conditions for guaranteeing private property and creating an attractive investment environment are analyzed.

**Keywords:** diverse ownership, competitive environment, economic growth, business environment, property security, incentives, savings, digitization.

**Introduction.** Development of a stable economy in the Republic of Uzbekistan, raising the standard of living of the population, eliminating economic problems such as unemployment and shortages through the development of an economy based on diverse ownership is on the agenda. It is also known from the experience of foreign countries with highly developed economies that the basis of the

economy based on different ownership allows to improve the quality of production and services in a competitive environment, to develop modern goods and services that meet the needs of the population, to saturate the markets and to make prices cheaper. In particular, through the development of small business and private entrepreneurship, not only the state, but also every family, every person's endlessly

growing needs will be adequately met. Small business and private entrepreneurship are important because they can quickly adapt to the market, which drastically reduces the level of monopolization of the economy. For this reason, the country's economic growth cannot be imagined without the development of entrepreneurs and small business entities.

At the same time, ensuring the rapid growth of small business and private entrepreneurship, creating a business environment by the state, improving the organizational and legal mechanisms of small business and private entrepreneurship based on the changing conditions for entrepreneurs, eliminating administrative obstacles for business entities, guaranteeing private property and Creating an attractive investment environment is one of the measures that should be implemented continuously.

**Analysis of literature on the topic.** Theoretical and methodological aspects of small business and private entrepreneurship development A. Smith, J. Foreign scientists such as Schumpeter, F. Hayek, A. V. Busigin, A. I. Ageev, B. A. Leshenko, P. A. Guryanov, F. F. Khamidullin, Ya. S. Yadgarov, A. V. Kirillov and the potential of small business and private activity and the need to regulate it by the state scientific research of H.P.Abulqosimov, Q.Muftaydinov, U.V.Gafurov, N.K.Murodova, G'.P.Sharipov, A.Olmasov and other scientists of our republic described in the works.

**Research methodology.** Methods such as observation, comparison, systematic and comparative analysis were used during the research work.

**Analysis and results.** In Uzbekistan, priority is given to the advantages of small business and private entrepreneurship development, and measures to regulate and support this sector by the state are becoming more active. After all, it was concluded that small business and private

entrepreneurship activities are the prosperity of the country. For this reason, the number of small business entities is increasing year by year.

However, in comparison with the indicators of foreign countries with developed small business and private entrepreneurship, the fact that we have not yet reached a sufficient level in this field and there is a lot of work to be done, shows the need to generalize and study the experiences of developed countries.

Foreign experiences in the development of small business and private entrepreneurship activities and state regulation show that one of the main directions of state policy in developed countries is aimed at supporting the private sector, and they are especially focused on improving it based on changing conditions and being able to quickly change based on market requirements. allows for development.

The structure of support for small business and private business entities through economic mechanisms is implemented through the provision of tax and duty benefits, the use of a simplified taxation system, the allocation of preferential and purpose-oriented loans and subsidies, in which the state is the main reformer and strengthens through legal means. At the same time, the state supports the activities of educational institutions that train personnel for entrepreneurship at the expense of its own funds, and creates a material basis for the formation of the middle class of owners.

2019 of the President of the Republic of Uzbekistan "On additional measures to fundamentally improve the system of organizing work for the protection of private property and strengthening the guarantees of the rights of owners, supporting entrepreneurial initiatives, as well as expanding the opportunities of business entities to use financial resources and production infrastructure" Decree No. PF-5780 of August 13, establishing the inviolability of private property, the seizure

of private property for any reason, including previously privatized property, the demolition of property, and the prevention of arbitrariness in the allocation of land plots, small business and private entrepreneurship activities brought its development to a new stage [1].

According to the 29th goal of the 3rd direction of the Development Strategy of New Uzbekistan for 2022-2026 entitled "Rapid development of the national economy and ensuring high growth rates", approved by the Decree of the President of the Republic of Uzbekistan No. UP-60 dated January 28, 2022 "to create conditions for the formation of resources, to

increase the share of the private sector in the gross domestic product to 80% and the share of exports to 60%" [2] means the future perspective of the development of the private sector in our country.

As of 2023, as of 2023, the total number of registered small business entities has reached 523,556 during the activities being carried out to support and encourage the development of small business and private entrepreneurship, and to create favorable conditions and environment for their free operation. Compared to 2019, their number is almost doubled [5].

**Table 1**  
**The share of small business and private entrepreneurship in economic sectors in the Republic of Uzbekistan (as a percentage of the total volume)[5]**

Indicators	2019 year	2020 year	2021 year	2022 year	2023 year	2023 vs. 2019 (in percent)
Industry (billion soums)	83344,2	103020,8	124907,9	143892,7	119088,5	142,9%
Construction (billion soums)	53960,9	63866,6	77907,1	93554,5	79990,5	148,2%
Employment (thousand people)	10318,9	9865,7	10080,6	10131,1	10278,9	99,6%
Export (million dollars)	4714,8	3100,9	3335,2	5712,9	5332,4	113,1%
Import (million dollars)	14972,2	10943,3	11533,5	15213,6	13440,6	89,8%

If we analyze the share of small business in economic sectors in our country in 2023, its share in industry was 142.9%, its share in construction was 148.2%, and its share in export of goods and services was 113.1%, compared to 2019.

The experience of Asian, European and American countries with highly developed market economies shows that without identifying the problems of entrepreneurship and small business development and finding their solutions, economic growth, alleviating social problems, increasing the income of the population, filling the consumer market with quality services and goods, the country's

export It is a difficult issue to implement important tasks such as capacity building.

Small business and private entrepreneurship activities require state support in one form or another. The need to support business activities arises from a number of circumstances. Most of the business entities are relatively small and have limited opportunities. This leads to a relative decrease in the competitiveness of commodity services and profits. The profits they receive do not allow for the necessary growth and implementation of a strong competitive strategy. If they are not supported, most of them will break. Effective use of limited resources, obtaining techniques and technologies on the basis of benefits, introduction of new

ones, provision of specialists and other issues rely on state support [4].

Despite the efforts made in the development of small business and private entrepreneurship in Uzbekistan, it is necessary to further strengthen the protection of private property and the guarantees of the rights of owners, to give additional impetus to the development of entrepreneurship, to support entrepreneurial initiatives and projects, to expand the opportunities of business entities to use financial resources, there is a need to increase the level of social coverage in places.

The experience of foreign countries with developed economies shows that the private sector develops mainly in the service sector. In such countries, the service sector has taken a decisive place and its share in the gross domestic product is 60-80 percent. In this sector, 80% of the employed population in the economy, 50-60% in Western European countries work in the service sector [3].

Therefore, it is appropriate to create a more favorable business environment in Uzbekistan, to summarize the available opportunities, and to implement state support measures based on a special approach in areas with high entrepreneurial efficiency.

**Conclusions and suggestions.** In the conditions of the market economy, small business and private entrepreneurship is the main driving force of the economy. It is difficult to imagine a market economy without small business

and private entrepreneurship. Limited opportunities in business entities mean the need for state support. At the same time, it comes from the need to alleviate social problems by supporting business entities, curb monopoly, create a competitive environment and saturate the consumer goods market. Therefore, in the conditions of the modern market economy, the state maintains the principle of the main reformer and carries out a policy of supporting entrepreneurship.

As a result of the ongoing scientific research, the following conclusions can be drawn in order to further develop small business and private entrepreneurship, to further improve the mechanism of its state support:

usually more attention is paid to the economic and legal means of state support of business activities. In our opinion, attention should be paid to social factors at the same time. Because in many cases, entrepreneurs are unaware of the ongoing reforms and changes, adopted legal documents, lack of information. Therefore, it is necessary to increase measures to strengthen entrepreneurship culture;

state support for small business and private entrepreneurship should be based on regional characteristics;

it is necessary to systematize the interdependence of legal, social and economic factors of business support;

it is necessary to improve state support for business activities based on changing conditions.

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